McMaster University | HEALTH FORUM

Rapid Synthesis

Achieving net-zero emissions in health systems through strategic funding partnerships and networks

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Appendix 1: Methods

Background to the rapid synthesis

This rapid synthesis mobilizes both global and local research evidence about a question submitted to the McMaster Health Forum's Rapid Response program. Whenever possible, the rapid synthesis summarizes evidence drawn from existing evidence syntheses (primarily systematic reviews) and from single research studies in areas not covered by existing evidence syntheses and/or if existing evidence syntheses are old or the science is moving fast. A systematic review is a summary of studies addressing a clearly formulated question that uses systematic and explicit methods to identify, select and appraise research studies, and to synthesize data from the included studies. The rapid synthesis does not contain recommendations, which would have required the authors to make judgments based on their personal values and preferences.

The Forum produces timely and demand-driven contextualized evidence syntheses such as this one that address pressing health and social system issues faced by decision-makers (see our website for more details and examples). This includes evidence syntheses produced within:

- days (e.g., rapid evidence profiles or living evidence profiles)
- weeks (e.g., rapid syntheses that at a minimum include a policy analysis of the best-available evidence, which can be requested in a 10-, 30-, 60- or 90-business-day timeframe)
- months (e.g., full evidence syntheses or living evidence syntheses with updates and enhancements over time)

This rapid synthesis was prepared over a 30-business-day timeframe and involved five steps:

1) submission of a question from a policymaker or stakeholder (in this case, staff leading an initiative on net-zero emissions at the Canadian Medical Association)
2) identifying, selecting, appraising and synthesizing relevant research evidence about the question
3) conducting and synthesizing a jurisdictional scan of experiences about the question from other countries and Canadian provinces and territories
4) drafting the rapid synthesis in such a way as to present concisely and in accessible language the research evidence
5) finalizing the rapid synthesis based on the input of at least two merit reviewers.

Identification, selection, quality appraisal and synthesis of evidence

To identify evidence about health-system emissions mitigation and adaptation strategies, about barriers to these strategies, and about strategic partnerships and funder networks to overcome them, we built on searches conducted as part of a rapid evidence profile completed to answer the question: "What do we know from the best available evidence and experiences about the nature and scale of health-system emissions, mitigation and adaptation strategies to achieve net-zero health-system emissions, and processes to achieve net-zero health-system emissions?"(1) Initial searches conducted as part of this rapid evidence profile identified 17,105 documents as of the end of 2021. Of these documents, 1,374 mentioned emissions, healthcare sector and carbon footprint. Each of the 1,374 documents were assessed by a single reviewer to identify those relevant to the question. In addition, each of the included single studies were categorized by one reviewer according to the forms of evidence profiled in the Evidence Commission report (data analytics, modelling, evaluation, behavioural/implementation and/or qualitative insights).

We supplemented and updated this dataset by searching for newly published evidence syntheses (primarily systematic reviews) in Health Systems Evidence, Social Systems Evidence and PubMed in January 2024, excluding duplicates that had previously been identified. In Health Systems Evidence we used keyword searches for "climate change" OR "emissions" and combined these with filters under 'type' for 'overviews of evidence syntheses,' 'evidence syntheses of effects,' and 'evidence syntheses addressing other questions.' In Social Systems Evidence, we applied filters under programs and services for "climate action," "environmental conservation," "food safety and security," and "natural resources" and combined it with the same document-type filters noted above, as well as "emissions" AND ("reduction" OR "mitigation") keywords. Additionally, we performed an advanced search in PubMed using the words ("emissions" OR "carbon footprint") AND ("reduction" OR "mitigation") AND "health sector" OR "hospital" AND "climate change" and combined these with filters for systematic review. Only documents focused on emissions mitigation or adaptation strategies were assessed for inclusion. Those focused solely on estimating or documenting the impact of healthcare on CO2 emissions were not considered eligible. A single reviewer assessed search results for inclusion to ensure they related to the question, and an additional 16 systematic reviews were included in the analysis.

A final inclusion assessment was performed by two members of the research team, with disagreements resolved by consensus or with the input of a third reviewer on the team. The team uses a dedicated virtual channel to discuss and iteratively refine inclusion/exclusion criteria throughout the process, which provides a running list of considerations that all members can consult during the first stages of assessment.

For any included guidelines, two reviewers assess each guideline using three domains in the AGREE II tool (stakeholder involvement, rigour of development and editorial independence). Guidelines are classified as high quality if they were scored as 60% or higher across each of these domains.

For each evidence synthesis we included, we documented the dimension of the organizing framework (see Appendix 2 for details about the framework used) with which it aligns, key findings, living status, methodological quality (using AMSTAR), last year the literature was searched (as an indicator of how recently it was conducted), availability of GRADE profile, and equity considerations using PROGRESS PLUS (where appropriate).

For AMSTAR, two reviewers independently appraise the methodological quality of evidence syntheses that are deemed to be highly relevant. Disagreements are resolved by consensus with a third reviewer if needed. AMSTAR rates overall methodological quality on a scale of 0 to 11, where 11/11 represents a review of the highest quality. High-quality evidence syntheses are those with scores of eight or higher out of a possible 11, medium-quality evidence syntheses are those with scores between four and seven, and low-quality evidence syntheses are those with scores less than four. It is important to note that the AMSTAR tool was developed to assess evidence syntheses focused on clinical interventions, so not all criteria apply to those pertaining to health-system arrangements or to economic and social responses. Where the denominator is not 11, an aspect of the tool was considered not relevant by the raters. In comparing ratings, it is therefore important to keep both parts of the score (i.e., the numerator and denominator) in mind. For example, an evidence synthesis that scores 8/8 is generally of comparable quality to another scoring 11/11; both ratings are considered 'high scores.' A high score signals that readers of the evidence synthesis can have a high level of confidence in its findings. A low score, on the other hand, does not mean that the evidence synthesis should be discarded, merely that less confidence can be placed in its findings and that it needs to be examined closely to identify its limitations. (Lewin S, Oxman AD, Lavis JN, Fretheim A. SUPPORT Tools for evidence-informed health Policymaking (STP): 8. Deciding how much confidence to place in a systematic review. *Health Research Policy and Systems* 2009; 7 (Suppl1): S8.)

For primary research (if included), we documented the dimension of the organizing framework with which it aligns, publication date, jurisdiction studied, methods used, a description of the sample and intervention, hyperlinked title and key findings, and equity considerations using PROGRESS PLUS when appropriate/if applicable. We then used this extracted information to develop a synthesis of the key findings from the included syntheses and primary studies.

During this process we include published, pre-print and grey literature. We do not exclude documents based on the language of a document. However, we are not able to extract key findings from documents that are written in languages other than Chinese, English, French, Portuguese or Spanish. We excluded documents that did not directly address the research questions and the relevant organizing framework. All of the information provided in the appendix tables was taken into account by the authors in describing the findings in the rapid synthesis.

Identifying experiences from other countries and from Canadian provinces and territories

For each rapid synthesis, we collectively decide on what countries to examine based on the question posed. For other countries we searched relevant government and stakeholder websites. In Canada, we search websites from relevant national and provincial governments, ministries and agencies (e.g., Public Health Agency of Canada). While we do not exclude countries based on language, where information is not available in English, Chinese, French or Portugues or Spanish, we attempt to use site-specific translation functions or Google Translate.

Appendix 2: Framework used to organize what we looked for, and overview of which mitigation and adaptation strategies were the focus of the highly relevant research documents identified

We used a framework of mitigation and adaptation strategies to achieve net-zero health-system emissions from a previously conducted rapid evidence profile to categorize each of the evidence documents included in the rapid synthesis and to structure the presentation of findings in the rapid synthesis and appendices 3 and 4. We also reviewed the components of the World Health Organization Operational Framework for climate resilient and low carbon health systems focused on interventions and approaches to support low-carbon emissions in health systems and made minor adjustments to the original framework. We use **bold highlighting** to indicate the categories for which highly relevant evidence documents were identified (with non-bolded categories indicating that we did not identify any highly relevant evidence documents in our scan), and summarize the key findings for each of these categories in Appendix 4 (with additional details for each included evidence synthesis and single study included in Appendix 5 and Appendix 6).

- **Mitigation and adaptation strategies**
  - **Investments using a net-zero approach or requirement**
  - **Energy-use reductions**
    - **Buildings**
    - Energy production
    - Industry partners (e.g., IT partners)
    - Land use
    - **Transportation and travel**
  - **Low- or zero-carbon electricity supply and purchasing**
    - Nuclear power
    - **Renewable energy**
  - **Electrification and other fuel switching**
    - **Appliances**
    - Supporting infrastructure
    - **Vehicles**
  - **Non-energy emission solutions**
    - Bio-sequestration
    - Carbon capture and storage
    - Fugitive-emission reduction
    - **Industrial-process improvements**
    - **Reuse and recycling**
  - **Decarbonizing the supply chain**
    - **Food, catering and nutrition**
    - **Low-carbon inhalers**
    - **Anesthetic gases**
- **Processes, targets, and monitoring and evaluation strategy**

Appendix 3: Summary of what is known from highly relevant evidence documents about mitigation and adaptation strategies to achieve net-zero health-system emissions*

Mitigation and adaptation strategies for which highly relevant evidence was found		Summary of findings from highly relevant evidence about the strategies
Investments using a net-zero approach or requirement *Four evidence syntheses and two single studies identified*		Three systematic reviews (one high-, one medium- and one low-quality) found that despite the upfront costs of implementing strategies to reduce emissions, studies have demonstrated long-term cost savings. The best time to implement those strategies was identified as being during the planning and designing of new hospital buildings, where the initial capital costs have been found to represent less than 10% of total lifetime costs. The high-quality systematic review also reported that energy consumption is the highest source of emissions in the operating room. However, it is also where healthcare workers have less impact, and it was therefore identified that institution directors should invest in the construction of sustainable operating rooms. Another low-quality systematic review found no evidence of investments in emergency departments to reduce greenhouse gas emissions. One single study found that net-zero emission measures were most likely to be implemented if the hospital directors' board were sufficiently pressured by staff and reputational fears. Moreover, it was found that measures were more likely to be adopted if the potential impacts of such measures were perceived to align with broader organizational aims or possess more significant financial co-benefits. Another single study highlighted purchasing rules to encourage manufacturers and vendors to produce and sell safe and environmentally clean resources could be used as an approach by healthcare organizations to reduce emissions.
Energy-use reductions	**Buildings** *14 evidence syntheses and one single study identified*	Regarding energy-use reduction in buildings, we identified two medium-quality systematic reviews and one low-quality systematic review focused on hospitals in general, and eight systematic reviews (three high quality, one medium quality and one low quality identified in initial searches, and an additional three medium-quality reviews in our updated searches) focused on operating rooms within hospitals. Our updated searches also identified: • two reviews that focused on specific clinical specialties, including a medium-quality review focused on environmental sustainability in the context of obstetrics and gynecology, and a medium-quality review focused on radiology (with the findings about mitigation and adaptation strategies related to building largely mirroring what the original searches identified) • a medium-quality systematic review focusing on the importance of targeting clinicians with behaviour-change interventions to help them improve their ability to contribute to reductions in emissions in the healthcare facilities within which they work. At the hospital level, one medium-quality review identified several categories of emissions mitigation and adaptation strategies that hospitals should consider, mostly focused on adopting energy efficiency measures and supportive green-building design decisions (e.g., measures to ensure efficient heating, lighting, and sustainable, non-polluting practices such as water reuse), and the second also identified similar strategies (and also covered other mitigation and adaptation strategies related to non-energy emissions solutions and decarbonizing the supply chain). This second review also emphasized the importance of increasing staff knowledge and awareness of sustainability and the impact of health facilities on the environment), and framed it as a major barrier to advancing efforts in this space. The low-quality systematic review reported several building interventions such as co-generation of energy (heat and power) using gas-fired co-generation, solar thermal cooling and ground-sourced heat pumps. One single study also suggested that hospital buildings should maintain appropriate internal temperatures in areas with different temperature needs, such as in emergency rooms and clinics, in contrast with the waiting rooms and the administration offices. This study also suggested using automatic doors in frequently used hospital entrances to minimize energy losses. The operating room was the most common service addressed in the evidence documents reviewed, given that operating rooms have been identified as having the largest carbon footprint at the hospital level. The five systematic reviews identified during initial searches focused on addressing operating rooms were consistent in noting that the implementation of occupancy sensors or energy-efficient scheduling for using HVAC systems are essential strategies to reduce global greenhouse gas (GHG) emissions in the operating room. In addition, two systematic reviews (one high quality and one low quality) reported that radiofrequency identification systems, which automatically turn on and adjust

Mitigation and adaptation strategies for which highly relevant evidence was found		Summary of findings from highly relevant evidence about the strategies
		themselves according to the number of persons in the operating room, have been shown in a pilot study that they perform correctly in 98–99% of the cases and could generate 50% energy savings. The two reviews identified focused on clinical specialties aligned with the findings above, and noted the general importance of improving energy efficiency (e.g., in obstetric operating theatres) and on performance audits in clinical settings (e.g., in the context of clinical radiology and radiology departments in hospitals more generally). One of the medium-quality reviews identified in updated searches emphasized the importance of surgeons building both intra- and inter-institutional 'green teams' to collaborate with environmental organizations as a way to learn more about strategies for improving sustainability. The speciality-care focused review in the context of clinical radiology also noted the importance of supporting implementation of sustainability measures through the establishment of working groups, and complementing this approach by incorporating sustainability training into healthcare professional education programs. Another medium-quality review identified in updated searches highlighted significant implementation challenges associated with strategies to improve the environmental sustainability of operating theatres, noting a lack of evidence available about the best ways to integrate mitigation and adaptation strategies – despite some promising qualitative insights suggesting targeting behaviour-change strategies on health professionals is promising. The third newly identified medium-quality review identified similar mitigation and adaptation strategies identified in the other reviews identified (some of which relate to buildings more generally and others to non-energy emissions solutions such as reuse and recycling and industrial-process improvements, which are noted lower in this table) but also identified the importance of considering implementation strategies, calling for more effort to evaluate implementation given a lack of evidence and more generally a lack of widespread implementation of known mitigation and adaption strategies in surgical departments. Other strategies for reducing GHG emissions in the context of healthcare facilities/buildings were water-cooling systems, low-energy lighting, retrofitting insulation, energy-efficient windows and heat or coolness recovery devices. One high-quality systematic review indicated that improving the energy efficiency of hospitals in the U.S. by 30% has been estimated to save $1 billion USD and a reduction in carbon emissions of 11 million tonnes. One low-quality systematic review reported no difference in the microbiological load of air samples from operating rooms where the ventilators are turned off idle overnight compared with those with continuous ventilator usage.
	Transportation and travel *Fourteen evidence syntheses and three single studies identified*	Regarding the energy-use reduction in transportation, two systematic reviews (one high quality and one low quality) indicated that staff/patient travel to the hospital is responsible for 10–37% of the carbon footprint in the healthcare sector. Strategies to reduce the carbon footprint due to transportation include technical changes oriented to encourage teleconferencing and telemedicine (one high-quality, two medium-quality, one low-quality systematic reviews, one single study), improving public transport services, and encouraging car-pooling, cycling, and active travel (one high-quality, one medium-quality, one low-quality systematic reviews, two single studies), and setting limitations on or banning free parking inside the hospital premises (one single study). One medium-quality systematic review focused on evaluating the carbon footprint of telemedicine reported a reduction greater than 95% in the carbon burden compared with in-person healthcare delivery. Carbon savings ranged from 0.69 kg CO2e (carbon dioxide equivalent) to 893 kg CO2e per encounter; distances saved ranged from 6.1 to 3,386 km, and cost savings went from 1.73 euros in fuel costs to over $900 USD in travel-related expenses. One single study in Canada found that providing outreach clinics when healthcare is regionalized might reduce up to 2.5% of the individual's yearly carbon footprint. Nine additional systematic reviews were identified in updated searches that focused on efforts to reduce emissions through less travel: • two medium-quality reviews focused on hospitals and other healthcare facilities, with the first including active and low-emissions/alternative travel as part of a comprehensive framework for reducing hospital emissions and enhancing sustainability, and the second identifying it as a core component of reducing greenhouse gas emissions • one medium-quality review focused on environmental sustainability in gynecology and obstetrics concluded that increasing the number of virtual visits to reduce transportation should be considered, with one included study estimating that converting 50% of gynecological oncology outpatient consultations to telemedicine could prevent 6.25 tonnes of CO2 emissions related to the avoided travel in

Mitigation and adaptation strategies for which highly relevant evidence was found		Summary of findings from highly relevant evidence about the strategies
		one month, and another medium-quality review focused on emissions in radiology also noted the potential to reduce emissions through reduction in staff and patient travel • three reviews identified also specifically focused on evaluating telemedicine, telehealth or virtual visits, with one low-quality review and one medium-quality review both indicating the potential benefits of switching to virtual visits (although the total potential reduction in emissions was found to vary by factors such as speciality, sector geography and time), and one low-quality review noting that more effort is needed to estimate the full extent of emissions associated with new digital-health technologies (e.g., manufacturing, waste and energy use), given many current estimates only include the impact through reduced travel • two other medium-quality reviews – one focused on emissions from microbiology labs and the other on supporting behaviour change among clinicians to reduce emissions in clinical activity – both noted the importance of ensuring clinicians are making decisions (such as ordering fewer unnecessary tests to reduce transportation of specimens to labs, or requiring in-person consultation) that can reduce emissions, and that efforts to support this type of behaviour change may be useful
Low- or zero-carbon electricity supply and purchasing (renewable energy) *Three evidence syntheses and one single study identified*		One medium-quality and one high-quality systematic review indicated that surgical systems need to switch to renewable rather than fossil fuel–based energy sources, which cannot occur without overall energy-sector decarbonization. Another medium-quality systematic review focused on hospitals more generally found that mitigation and adaptation strategies should include energy efficiency, ideally through switching to renewable and clean energy and aligning facilities within the hospital to reduce fossil-fuel consumption. This same review also noted the importance of implementing laws that support the adoption of purchasing practices that prioritize green energy sources. One single study performed in Greece found that the increase of renewable energy sources and gas-fired plants, and the shutting down of lignite-fired power plants in the country by 2028, will have a positive impact on reducing indirect GHG emissions in the healthcare sector.
Electrification and other fuel switching	**Appliances** *One evidence synthesis and one single study identified*	Regarding electrification of appliances, one medium-quality systematic review found that the energy demand for lighting and machinery could be reduced by replacing older equipment with more energy-efficient options, such as light-emitting diode (LED) lights. One single study found that it is necessary for hospitals to gradually replace stationary air conditioning systems and freezers with appliances that are more energy efficient.
	Vehicles *Three single studies identified*	Regarding electrification and fuel switching of vehicles, three single studies (one data analytics, one implementation and one economic evaluation) focused on the carbon footprint of ambulances. One study conducted in Australia found that for ground ambulance operations, emissions averaged 22 kg of carbon dioxide equivalents per ambulance response. Vehicle fuels accounted for 58% of the emissions, with the remainder primarily attributable to electricity consumption. To reduce the carbon footprint of ambulances, two studies suggested using biofuels. Another study evaluated the possibility of electric ambulances, and one study recommended the use of hybrid vehicles for administrative and support-vehicle fleets. One study also suggested making changes in the routine use of ambulances, for instance, reducing unnecessary ambulance responses and transports, developing flexible response-time policies, reducing driving speeds when transporting stable patients without life-threatening conditions, and reducing ambulance idling at emergency scenes and receiving hospitals.
Non-energy emission solutions	**Industrial-process improvements** *Seven evidence syntheses and two single studies identified*	Regarding industrial-process improvements, our original searches identified one high-quality systematic review that found the sterilization process can be done more efficiently and cleanly. The review indicated that although hospitals have modernized their sterilization process, opening the ability to reuse disposables, there is an evidence gap about the ecological impact of this change. When studies compare disposable and reusable devices, the process of sterilization of reusable devices results in equivalent or lower GHG emissions as compared to using disposable devices. Moreover, the review noted that a design permitting low-effort cleaning and sterilization, which decreases water and energy consumption for reusable equipment, could be a promising lead for further reducing the environmental impact of sterilization. We identified an additional six systematic reviews in our updated searches that addressed industrial-process improvements with most focusing on the benefits of green-purchasing initiatives that emphasize the importance of considering emissions when procuring medical equipment. For example, one medium-quality review focused on environmental sustainability in the context of specialist gynecological services found that displacing disposable with reusable materials and minimising content of surgical custom packs was the most promising strategy for reducing

Mitigation and adaptation strategies for which highly relevant evidence was found		Summary of findings from highly relevant evidence about the strategies
		environmental impact. Another medium-quality review on the determinants and actions of climate-adaptive hospitals developed a framework that highlighted the importance of adopting green-purchasing practices that emphasized renewable and sustainable equipment that minimizes waste, and this was also highlighted as an important emissions-reduction practice in a third medium-quality review. The fourth review (also medium quality) focused on sustainable surgical practices, and focused on the impact of reusable devices vs. single-use devices and their impact on emissions, finding that studies reporting a benefit with reusable devices reported 40–66% lower emissions than with single-use alternatives; however, in studies not showing a lower carbon footprint, the reduction in manufacturing emissions was offset by the high environmental impact of local fossil fuel-based energy required for sterilization, and the per-use monetary cost of reusable equipment was 47–83% of the single-use equivalent. Additionally, a fifth medium-quality review focused on radiology practice found that equipment manufacturers and service engineers could adopt remote equipment servicing and integrate the use of AI in new CT scanners to reduce overall energy emission per scanning case and to help eliminate the need for repeat scans. The sixth additional review of low quality we identified; focused on analyzing a specific type of reusable flexible cystoscopes and a proprietary single-use cystoscope, and identified two studies which both found reprocessing was the most significant factor when considering the environmental impact of reusables, but calculations of the emission linked to the reprocessing of the instruments differed greatly. One single study using data analytics reported the mean CO2e emissions of the magnetic resonance (17.5 kg/scan), computed tomography (9.2 kg/scan), chest X-ray (0.8 kg/scan), and ultrasound (0.5 kg/scan). The study recommends that clinicians and administrators can reduce carbon emissions from diagnostic imaging by implementing different strategies when they are clinically appropriate. For instance, this can be accomplished by reducing unnecessary imaging, ordering low-impact imaging (X-ray and ultrasound) instead of magnetic resonance and computed tomography, turning off scanners to reduce emissions from standby power, and ensuring high utilization rates for scanners reducing standby times. One single study in the U.K. reported that pharmaceuticals contribute nearly a quarter of the CO2 emitted each year by the health sector. Factors contributing to pharmaceutical carbon emissions include over-prescription, pharmaceutical waste, antibiotic resistance, routine prescriptions, non-adherence, drug dependency, lifestyle prescriptions and drugs given due to a lack of preventive healthcare.
	Reuse and recycling *10 evidence syntheses and one single study identified*	Six systematic reviews and one single study that addressed reuse and recycling were identified in our original searches. Four of the systematic reviews focused on waste in the operating room. Three high-quality systematic reviews and one low-quality scoping review suggested switching to reusable items, reducing resource use where clinically appropriate, reprocessing surgical instruments and improving waste segregation. One high-quality systematic review found that reprocessing single-use surgical instruments might reduce the GHG emissions of an entire operation by 9%, costing half the price of single-use equivalents. The same review also found several studies examining the carbon footprint of surgical scissors, laparotomy pads, and suction receptacles, showing that emissions can be reduced by 50–97% through switching from single-use to reusable surgical devices. Another high-quality systematic review found that reusable items could substantially improve sustainability, with a 70% reduction in waste generation, threefold lower water consumption, and 2.5-fold lower energy consumption. One medium-quality systematic review highlighted strategies to maximize equipment lifespan and reduce emissions per use. According to this review, several studies have demonstrated reusable equipment to be environmentally superior to single-use devices (SUDs) for a wide range of equipment and procedures, potentially reducing GHG emissions by up to 90%. The review suggested that purchasing policies should be guided by environmental values, selecting equipment and consumables based on long-term financial and ecological costs rather than upfront costs. One study reported that 13% of disposable items opened for neurosurgical procedures are discarded without use and, therefore, changing processes to only open equipment when needed and reducing the number of rarely used instruments could bring financial and carbon savings. A high-quality systematic review found six studies concluding that reusable textiles had substantially better environmental profiles than disposable textiles, which increase energy use and carbon footprint by 200–300%. As one example, choosing reusable surgical gowns over disposable gowns reduced energy consumption by 64% and the carbon footprint by 66%. Moreover, the U.S. Centers for Disease

Mitigation and adaptation strategies for which highly relevant evidence was found		Summary of findings from highly relevant evidence about the strategies
		Control and Prevention (CDC) concluded that no data suggests important differences between reusable and disposable gowns and drapes in terms of the prevention of surgical site infections. One low-quality scoping review found that approximately 30% of all hospital waste is paper/cardboard and a similar proportion is plastic, indicating high recycling potential. In addition, two high-quality systematic reviews highlighted that recycling could usually be implemented as an extension of national domestic recycling programs. On a broader scale, it has been estimated that streamlining and optimizing resource use in operating rooms can save approximately $9 million USD per NHS trust in the U.K. each year. Reprocessing single-use devices in the U.S. might save about $20,000 USD per operating room annually. However, the move to single-use items has not been well studied, and decisions appear to be driven by factors other than infection control practices, such as cost, ease of use, difficulty making some reusable items patient-ready again, doctors' preferences and marketing. In addition, one high-quality systematic review concluded that the use of reusables is only more sustainable if there is the infrastructure to efficiently reprocess the items. For instance, in Australia, reuse had monetary benefits, but it resulted in a 9% increase in emissions compared to the 84% and 48% decreases seen in the U.K. and U.S., respectively. This difference is mainly due to Australia still having 75% of its electricity generated from coal, which is a stark contrast to 1% in the U.K. The additional systematic reviews that were identified in our updated searches all reported findings that were aligned with those outlined above: • a medium-quality review focused on supporting climate-adaptive hospitals highlighted the importance of reuse and recycling across a number of the practices that their framework suggested hospitals should adopt (e.g., water reuse, purchasing sustainable and reusable equipment and furniture, building with renewable and 'green' materials), and a second medium-quality review focused on green practices in healthcare facilities also highlighted the importance of waste management and green-purchasing, which included aspects of reuse and recycling • a medium-quality review focused on obstetrics and gynaecology identified the importance of reusable instruments and materials, a second medium-quality review focused on surgery specifically also identified the importance of reusable equipment and textiles (in addition to recycling and correcting waste segregation) and a third medium-quality review focused on radiology also highlighted the importance of the 'controlled use' of resources (which include considerations about their ability to be recycled and reused) as a key consideration for decision-makers trying to reduce emissions. One single study performed in a large Western healthcare organization in Canada investigated how employees should engage with environmentally responsible use of resources at the workplace. The study found that organizational policies that discussed the utilization or conservation of healthcare resources did not mention the climate or environmental impact of these activities. However, waste-management policies were the only ones that explicitly prioritized reducing healthcare's environmental impact. Specifically, these policies aimed to reduce the potential for toxic chemical spills or other scenarios where possible environmental contamination could occur.
Decarbonizing the supply chain	**Food, catering and nutrition** *Three evidence syntheses and one single study identified*	Our updated searches identified three systematic reviews that focused on how food, catering and nutrition could contribute to decarbonizing the supply chain, specifically in the context of hospitals and other health facilities. One medium-quality review found a number of strategies that hospitals could use to reduce emissions through better practices related to food, which included: a healthy food program that emphasized purchasing food products that require less transportation, providing meat-free options that contribute less to emissions, prohibiting the use of frozen foods, identifying opportunities for donating food waste that can contribute to biofuel and composting and considering how food supply chains can be optimized to reduce emissions. Another medium-quality review identified 'food optimization' as a key area where hospitals could reduce greenhouse gas emissions (namely through procurement that takes emissions into consideration). A third medium-quality review focused on integrating sustainable nutrition into professional practice (e.g., ensuring professionals are advising patients about

Mitigation and adaptation strategies for which highly relevant evidence was found		Summary of findings from highly relevant evidence about the strategies
		food options that have low environmental impacts), and identified a number of actions, mostly to be targeted to individual professionals, that are needed to overcome barriers to doing so, including: updating practice guidelines and actions plans, distributing them to practices for different professions and provide indicators to track progress, initiating training opportunities and teaching tools on sustainable nutrition, and undertaking information campaigns to align social expectations with the values and practices of health organizations and professionals. One single study conducted in Portugal addressed food, catering and nutrition, and found that, on average, each patient throws away 953 g of food each day, representing 35% of the food served. This equates to 8.7 thousand tonnes of food waste being thrown away each year at hospitals across Portugal. Based on this, five measures were identified to reduce food waste, which included bread on-demand, switching from a plated to a bulk system for meal delivery, allowing patients to choose a portion size, increasing menu options, and prompt update of empty beds to detect and record last-minute changes to the number of meals required.
	Low-carbon inhalers *Two evidence syntheses and two single studies identified*	Updated searches identified two medium-quality systematic reviews that addressed the role of low-carbon inhalers on reducing emissions (in addition to the two single studies identified in our original searches). The first medium-quality review found that studies show the potential for reducing the carbon footprint of inhalers by switching to dry-power inhalers (from pressured metered-dose inhalers), but that the clinical outcomes associated with this shift are uncertain. The second medium-quality review was focused on implementation strategies – and in particular behaviour-change interventions targeted to clinicians to help them reduce emissions – identified a study that focused on supporting clinicians to prescribe low-carbon inhalers. The review identified the following promising strategies to promote emissions-reduction behaviours, including social support, salience of consequences, restructuring the physical environment, prompts and cues, feedback on outcome of behaviour, and information about environmental consequences; however, while the success of these interventions was reported, each study included very few provide estimates of effectiveness. Low-carbon inhalers were addressed in two single studies. One study found that suboptimal respiratory treatment, in the form of short-acting β2-agonists (SABAs) overuse across Europe and Canada, remains widespread and represents approximately two-thirds of total GHG emissions for respiratory treatment. The second study identified different strategies for reducing the carbon footprint of inhalers, including: reducing the use of short-acting beta-2 agonist (SABA) "on-demand" in all types of inhalers; supporting optimal use of the inhalation chamber; using inhalers for the last dose and not wasting doses by releasing the drug into the atmosphere; introducing inhalers with new propellants with lower global warming potential values; using rational replacement of metered-dose inhalers by dry powder inhaler or metered-dose liquid inhaler; and promoting the recycling of all inhalers.
	Anaesthetic gases *Six evidence syntheses and two single studies identified*	Three systematic reviews and two single studies that addressed anesthetic gases were identified in our original searches. One medium-quality systematic review reported that inhaled anesthetic agents are potent greenhouse gases, including desflurane which has the most significant global warming potential (more than 2,000 times that of CO2, while another agent (sevoflurane) is only 130 times as potent as CO2. Disproportionate use of desflurane has been found to be responsible for up to 80% of GHG emissions in operating rooms in high-income countries. As result, the review found that systematically switching from desflurane to sevoflurane can lead to a 10-fold reduction in carbon footprint and significant cost savings. In addition, two high-quality systematic reviews found that reducing the use of desflurane has a more powerful potential impact on global warming than other agents. One of these reviews reported that a combination of staff education, lower gas flows and promotion of IV anesthesia leads to a 25–55% decrease in the usage of desflurane. The other review highlighted that healthcare workers should consider alternative anesthetic options such as local, regional, or total intravenous anesthesia after consultation with anesthesiologists. One single study in Australia also found that staff education on desflurane-sparing practices, distribution of posters, and progressive removal of desflurane from operating rooms are effective strategies to reduce their use. After implementing these strategies, the number of desflurane bottles purchased decreased by 96%, the number of sevoflurane bottles bought increased by 6%, combined desflurane and sevoflurane emissions decreased by 88% and costs decreased by 59%. One single study focused on dentistry services reported that reducing the use of nitrous oxide would be beneficial for the environment, but managing patients with nitrous oxide is often the only alternative to intravenous sedation or general anesthetic, both of which have a higher carbon footprint than nitrous oxide.

Mitigation and adaptation strategies for which highly relevant evidence was found	Summary of findings from highly relevant evidence about the strategies
	The additional systematic reviews identified in updated searches – including one medium-quality review focused on surgery in general, a second medium-quality review focused on operating theatres more specifically, and a third medium-quality review focused on supporting behaviour-change among clinicians to reduce carbon emissions – all focused more generally on the need to reduce the use of anesthetic gases as an emissions-reduction strategy, and the ways that this could be achieved (e.g., through behaviour-change supports). However, these reviews noted that there is still a lack of evidence about the strategies that are most effective and sustainable.
Processes, targets, and monitoring and evaluation strategy *One evidence synthesis and three single studies identified*	One medium-quality systematic review was identified in updated searches, and focused on developing a checklist for measuring and monitoring the carbon footprint of healthcare facilities and technologies (with a focus on telehealth), to promote transparency and reporting. One single study summarized and compared initiatives contained in three toolkits for implementing sustainability and resiliency measures for healthcare facilities. The study compared the Canadian Health Care Facility Climate Change Resiliency Toolkit, the U.S. Sustainable and Climate Resilient Health Care Facilities Toolkit, and the PAHO SMART Hospitals Toolkit of the World Health Organization/Pan American Health Organization. The study found that in Canada, six facilities in Nova Scotia, Ontario and Manitoba have piloted the toolkit. The study also reported that facilities that have used the toolkit had become essential agents of change for reducing fossil fuel emissions, improving resiliency to extreme weather events, and advocating for public understanding of climate change and health. Educating providers on sustainability has been found to reduce the carbon footprint of the clinical practice of surgical-obstetric-anesthetic providers. Those strategies have reduced operating-room waste production by 50%, reduced GHG emissions from anesthesia care by 64%, and generated cost savings in high-income countries. The literature also recommends embedding climate change, recycling and waste segregation training into continuous medical education and routine training curricula.

**This table was developed by adapting the findings from a rapid evidence profile about the nature and scale of health-system emissions, mitigation and adaptation strategies to achieve net-zero health-system emissions, and processes to achieving net-zero health-system emissions,(1) by adding additional insights from the additional 16 systematic reviews identified in updated searches.*

Appendix 4: Summary of what is known from highly relevant research evidence about barriers to achieving net-zero emissions, and about the role of funding and investments to overcome them

Mitigation and adaptation strategies for which highly relevant evidence was found		Summary of findings about barriers to achieving net-zero emissions in health systems, about the role of funding and investments to overcome them, and about how partnerships can be structured to accelerate progress
Energy-use reductions	**Buildings** *Three evidence syntheses identified*	**Barriers** *Lack of clinical staff awareness of healthcare environmental impact* One medium-quality evidence synthesis found that clinical staff's lack of awareness about the environmental impact of healthcare was a contributing factor to minimal uptake of environmental sustainability practices and emphasized the importance of increasing staff knowledge and awareness of the impact of health facilities on the environment and their role in reducing the use of resources and implementing sustainability practices. **How partnerships can be structured to accelerate progress** *Partnering with clinicians* A medium-quality systematic review assessing behaviour change interventions implemented in healthcare settings highlighted the importance of partnering with clinicians to shift behavior and encourage them to reduce carbon emissions in the workplace. The review found that behaviour change interventions such as social support, prompts and cues, feedback on behaviour outcomes, and education about environmental consequences led to success in reducing carbon emissions, prescribing, ordering and costs. This finding was echoed in another medium-quality review exploring approaches to reduce the environmental impact of operating theatres that found that all behaviour change approaches reviewed were successful at achieving environmental improvement.
Electrification and other fuel switching	**Vehicles** *One evidence synthesis identified*	**Barriers** *Competing financial interests* In terms of vehicle-specific mitigation strategies, a low-quality systematic review that assessed environmental sustainability in hospitals highlighted that implementing financial incentives that are in the pecuniary interests of hospitals could be at odds with sustainability initiatives (e.g., rent received by the hospital from car parking versus lower fees for pooled cars or tax reimbursements for inter-hospital travel).

Appendix 5: Detailed data extractions from highly relevant evidence syntheses about health-system emissions mitigation and adaptation strategies

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available

Full systematic review (identified as part of evidence searches conducted as part of a related rapid-evidence profile)
• Investments using a net-zero approach or requirement
• Energy-use reductions
  ○ Building
  ○ Transportation and travel
• Low- or zero-carbon electricity supply
  ○ Renewable energy
• Electrification and other fuel switching
  ○ Appliances
• Non-energy emission solutions
  ○ Reuse and recycling
• Decarbonizing the supply chain
  ○ Anesthetic gases
• Processes, targets, and monitoring and evaluation strategy
	Title: Building sustainable and resilient surgical systems: A narrative review of opportunities to integrate climate change into national surgical planning in the Western Pacific region (2)
	
	Key findings:
	• Surgical care provision can be carbon intensive, and the health sector contributes about 4.9% of total global greenhouse gas (GHG) emissions
	• Operating rooms (ORs) are a highly resource-intensive component of the health system, and they can be three to six times more energy-intensive than the hospital average and consume 40–60% of a facility's supply chain
	• The main sources of GHG emissions from surgical procedures are equipment and consumables, inhaled anesthetic agents, and energy use; studies have shown that a combination of measures targeted at different sources can reduce the carbon footprint of ORs by 80–95%
	• Surgical system strengthening is essential in response to rising disease burdens from climate change, such as injuries from natural disasters
	• This review explored how climate change could be integrated into national surgical planning in the Western Pacific region; the review included 220 articles
	• Findings were categorized using the modified World Health Organization Health System Building Blocks Framework
	• Infrastructure
	  ○ Operating theatres are highly resource-intensive; their carbon footprint could be reduced by maximizing equipment longevity, improving energy efficiency, and renewable energy use
	  ○ Most emissions arise from the manufacturing process, therefore, there are important strategies to maximize equipment lifespan and reduce emissions per use; several studies have demonstrated reusable equipment to be environmentally superior to single-use devices (SUDs) for a wide range of equipment and procedures, potentially reducing GHG emissions by up to 90%
	  ○ Environmentally preferable purchasing policies could guide the selection of equipment and consumables based on their long-term financial and environmental cost rather than their upfront cost
	  ○ The number of instruments opened per case can be reduced to the minimum required; Thiel et al. found that minimizing the number of SUDs opened decreased GHG emissions in laparoscopic surgery (excluding anesthesia) by 70% in a United States hospital
	  ○ A more parsimonious approach to surgical trays has been demonstrated to be feasible and cost-effective
	  ○ ORs are highly energy intensive due to their unique requirement for stringent temperature and ventilation control for patient safety and microbial control; occupancy sensors or energy-
		No	5/9	2021	No

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available
	efficient scheduling, such as adapted weekend settings, could reduce HVAC energy consumption when ORs are not in use o The energy demand for lighting and machinery could be reduced by replacing older equipment with more energy-efficient options, such as light-emitting diode (LED) lights o Health systems with carbon-intensive electricity sources have substantially higher GHG emissions from energy use and surgical equipment reprocessing; therefore, it is necessary to engage the energy sector as part of decarbonization o Building climate-resilient infrastructure involves the whole health system and may, in some cases, necessitate relocating entire health facilities from disaster-prone sites o ORs are particularly vulnerable to climate extremes due to their strict ventilation and temperature requirements; white reflective roofs, retrofitting insulation, energy-efficient windows, and heat or coolness recovery devices could improve both OR energy efficiency and resilience to temperature extremes • Service delivery o Inhaled anesthetic agents are potent greenhouse gases; among them, desflurane has the greatest global warming potential (GWP), more than 2,000 times that of carbon dioxide (CO2), while sevoflurane is only 130 times as potent as CO2 o While patient safety must be the primary driver for anesthetic care delivery, several strategies could reduce its GHG emissions o Disproportionate use of desflurane has been found to be responsible for up to 80% of GHG emissions in ORs in high-income countries (HICs); systematically switching from desflurane to sevoflurane can lead to a 10-fold reduction in carbon footprint and significant cost savings o The use of volatile anesthetic agents could be profoundly limited by preferentially using total intravenous anesthesia and regional anesthesia when appropriate, and regional anesthesia could have additional advantages in low-resource and hard-to-reach settings, including cost, safety, OR efficiency, and the potential for task-shifting to non-specialist providers, thereby improving access as well as sustainability o Using low fresh gas flow or closed-circuit delivery can reduce the volume of volatile gas consumed by 20% o New technologies, such as Dynamic Gas Scavenging Systems or silica zeolite, can absorb, destroy, and even recycle anesthetic waste gases o The mode of surgical care delivery can also alter its carbon footprint, primarily due to CO2 use for insufflation and a greater number of single-use instruments o However, the mode of surgery depends on clinical conditions, and some are more effective in preventing complications and improving prognosis; therefore, studies examining long-term environmental impact are required before conclusions could be drawn, and the mode of surgery should be selected primarily based on clinical indications o Laparoscopic surgery has proven clinical benefits over open surgery in many circumstances; however, environmental impact should weigh more heavily into consideration where there is clinical equipoise, such as between robotic and laparoscopic surgery				

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available
	○ Innovative service-delivery models such as telemedicine and mobile outreaches have been found to reduce GHG emissions from patient travel while offering more accessible, patient-centred care ○ Office-based procedures when appropriate (i.e., skin procedures) • Workforce ○ Educating SOA (surgical-obstetric-anesthesia care) providers on sustainability has been found to reduce the carbon footprint of their clinical practice; focused educational initiatives have been successful in reducing OR waste production by 50%, and GHG emissions from anesthesia care by 64%, and generated cost savings in HICs ○ The literature also recommends embedding climate change into continuous medical education and routine training curricula; successful education programs have used personal narratives for emotional appeal and targeted the multidisciplinary team • Information management ○ Environmental sustainability should be incorporated as a key performance indicator for surgical systems in addition to other indicators • Research ○ Most of the studies included in this review have been conducted in HICs; aside from a few well-researched areas, such as heat-related birth outcomes and anesthetic gases, the evidence on this topic is still limited and dominated by commentaries and opinion pieces • Finance ○ Strategies to reduce emissions in SOA care often have significant financial co-benefits ○ Despite the upfront cost of capital purchases, studies have demonstrated substantial long-term cost savings from measures, such as improving building energy efficiency, reprocessing instruments, anesthesia gas scavengers and telemedicine ○ The results of life-cycle economic and environmental analyses must be considered by hospital managers, donors and financial mechanisms in supporting sustainable infrastructural upgrades • Governance ○ At facility level, institutional practices in procurement, energy use and service design should be shifted towards sustainability; environmentally preferable purchasing policies should be developed to guide sustainable procurement decisions ○ At national level, strategic planning in surgical system strengthening, climate change mitigation and adaptation, and disaster risk reduction should be closely integrated ○ Regulation and policies should facilitate sustainability where possible; for instance, SUD reprocessing can lead to environmental and cost benefits and is increasingly used in both HICs and low- and middle-income countries (LMICs) ○ SUD reprocessing is prohibited in many countries despite being shown to be safe in approved contexts; with more evidence being generated in the future, regulations could be updated to delineate the appropriate parameters around its use ○ At the international level, HICs produce substantially more GHG emissions from surgical care than LMICs; for instance, emissions from minimally invasive surgery alone in the United States are estimated to be higher than the gross national emission of some countries				

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available
	○ HICs in the region have both the responsibility and the ability to make a significant contribution to climate change mitigation by transforming their surgical systems				
Full systematic review (identified as part of evidence searches conducted as part of a related rapid-evidence profile) • Energy-use reductions ○ Building ○ Transportation • Low- or zero-carbon electricity supply ○ Renewable energy • Non-energy emission solutions ○ Reuse and recycling	Title: The Carbon Footprint of Surgical Operations: A Systematic Review (3) Key findings: • The U.S. healthcare sector produces 655 million tonnes of CO2 equivalents per year, contributing 8–10% of all national GHG emissions • In the U.K., the National Health Service (NHS) generates 22.8 million tonnes of CO2 per year, responsible for 6% of U.K. net CO2 emissions, and one quarter of all those produced by the public sector • Operating rooms make a large contribution to the healthcare carbon footprint as they are typically the most resource-intensive area of a hospital • Of U.K. NHS CO2 emissions, 59% are associated with the supply chain, of which the largest hotspot is medical instruments and equipment (responsible for 15.5% of total emissions) • Operating rooms generate 21–30% of hospital waste and are three to six times more energy-intensive than the rest of the hospital, which can be largely attributed to maintenance of the theatre environment (heating, ventilation and air conditioning) • This systematic review used a life-cycle assessment (LCA), a method used to account for several different environmental indicators (such as GHG emissions, eutrophication and ecotoxicity); only the carbon footprint component of LCA studies was considered in this review, and eight studies were included • The processes that are included within study inventory boundaries were classified according to GHG emission types (scope 1–3); scope 1 emissions are those directly emitted from a given organization (e.g., anesthetic gases), scope 2 emissions are indirect GHG emissions associated with electricity used by an organization (i.e., purchased directly by the hospital), and scope 3 gases incorporate all other indirect emissions (including those embedded within the supply chain, travel and waste disposal) • A carbon footprinting study is most reflective of true emissions where all processes attributable to the functional unit (from all three scopes) were included • The study found that the carbon footprint of a single operation ranged from 6 to 814 kg carbon dioxide equivalents • The studies found that major carbon hotspots within the examined operating theatres were electricity use, and procurement of consumables • Electricity was the largest source of GHG emissions, accounting for 63–78% of the carbon footprint of whole operations, and the amount of electricity consumed is likely to be closely linked with the operation duration • In two studies where electricity use was broken down, the highest consumption of electricity was for maintaining the theatre environment (heating, ventilation, and air-conditioning) ○ Approaches to minimizing electricity use include developing and installing occupancy sensors, low-energy lighting, energy efficient air-conditioning systems, and water-cooling systems	No	9/10	2019	No

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available
	○ Improving the energy efficiency of U.S. hospitals by 30% has been estimated to save $1 billion USD and a reduction in carbon emissions of 11 million tonnes ○ Electricity should also be switched to renewable rather than fossil fuel–based sources • By contrast, four studies found procurement to be the largest hotspot, with three specifically identifying single-use items to be largest contributors, responsible for up to 78% of the carbon footprint (with two of these studies referring to the same dataset) ○ Attention should be given to reducing this footprint, for example through switching to reusable items and reducing resource use where clinically appropriate, and considering reprocessing of surgical instruments ○ Studies examining the carbon footprint of surgical scissors, laparotomy pads, and suction receptacles found that this can be reduced by 50–97% through switching from single-use to reusable surgical devices ○ This is consistent with reports that favour reusable rather than disposable perioperative textiles and anesthetic items (anesthetic drug trays, laryngeal mask airways, and laryngoscope handles and blades) ○ Reprocessing of single-use surgical instruments is another potential target, modelled to reduce the GHG emissions of an entire operation by 9%, and costing half the price of single-use equivalents; however, reprocessing is not widely used in countries such as the U.K. or Australia ○ Seven single-use medical devices (including endoscopic trocars, ligatures, arthroscopic shavers and ultrasonic scalpels) found that reprocessed devices conferred lower global warming impacts alongside financial benefits ○ There is potential from streamlining surgical instrument trays through minimizing material use and selecting reusable surgical instruments ○ One study reported that 13% of disposable items opened for neurosurgical procedures are discarded without use, hence changing processes to only open equipment when needed could bring financial and carbon savings ○ On a broader scale, it has been estimated that streamlining and optimizing resource use in operating theatres holds the potential to save £7 million (approx. $9 million USD) per NHS trust in the U.K. each year • In the two studies that accounted for patient and staff travel to hospital, this was responsible for 10–37% of the footprint • It was possible to reduce the carbon footprint of surgery through improving the energy efficiency of theatres, using reusable or reprocessed surgical devices and streamlining processes				
Full systematic review (identified as part of evidence searches conducted as part of a related rapid-evidence profile) • Investments using a net-zero approach or requirement	Title: Environmental sustainability in hospitals – a systematic review and research agenda (4) Key findings: • The objective of this review was to establish the extent to which hospital environmental sustainability has been studied and the key issues that emerge for policy, practice and research; 76 studies were included in this review • Common research themes were identified: hospital design, direct energy consumption, water, procurement, waste, travel and psychology and behaviour	No	2/9	2013	No

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available

• Energy-use reductions
  ○ Building
  ○ Transportation
• Non-energy emission solutions
  ○ Reuse and recycling
	• Some countries (particularly the United Kingdom) have begun to invest systematically in understanding the environmental effects of hospitals
	• We found large variability in the extent of the evidence base according to topic; research regarding the architectural fabric of hospital buildings is at a relatively mature stage
	• Similarly, there is a developed research base regarding devices and technologies used within hospitals to reduce the environmental effects of direct hospital energy and water use
	• A significant part of the environmental footprint of hospitals relates to clinical practice (e.g., decisions regarding the use of pharmaceuticals and medical devices)
	• The effects of preventive or demand management measures that avoid unnecessary hospital procedures are likely to be much greater than incremental changes to how hospital procedures are performed
	• Hospital design
	  ○ The initial capital costs of a hospital building represent less than 10% of full lifetime costs
	  ○ This indicates the importance of incorporating energy efficiency at the planning and design stage for securing longer-term efficiencies
	  ○ Single patient rooms may be associated with reduced infection rates, but have greater initial costs and energy requirements compared with multi-use patient rooms; two reviews suggested that the benefits of single patient rooms are not yet proven, and that further research is needed to investigate the balance of costs and benefits
	• Energy
	  ○ Heating, ventilation and air conditioning typically account for at least half of direct hospital energy usage, with lighting and equipment accounting for most of the remainder
	  ○ Hospital ventilation is routinely left running continuously, including within ORs that are unoccupied overnight; there is, however, evidence of no difference in the microbiological load of air samples from ORs where the ventilators are turned off in idle ORs overnight, compared with ORs with continuous ventilator usage
	• Water
	  ○ Hospitals use considerable amounts of water (e.g., 1% of a city's total water consumption)
	  ○ Within a hospital most of the water use occurs in four areas: wash basins, sinks and showers (20–40% of total), toilets (15–30%), laboratories, cooling towers, macerators and sterilizers (15–40%) and food preparation (5–25%)
	  ○ Water savings of 10–25% can be achieved through simple means which do not require further innovations or research: auditing usage including installing data-logging metres and sub-metering, checking for leaks, applying flow restrictors on hand basins and showers, installing dual-flush toilets and reclaiming water from dialysis units and sterilizers
	  ○ Significant water savings are possible (hundreds of litres/tap/day) from altering the surgical hand scrub whether through water-saving devices such as automatic tap timers or replacing water use with other disinfectants
	• Travel				

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available
	○ Hospital travel incorporates ambulance, private and public transport, and car travel is a major contributor to CO2 emissions; it is estimated that 16% of carbon emissions related to healthcare are attributable to staff/patient travel ○ The research agenda for improving the sustainability of hospital travel can be subdivided into technical, financial and social ○ Technical changes may lead a transformation of hospital travel; improved teleconferencing/telemedicine can reduce travel demand for business, patient and staff leading to financial, environmental and time savings ○ Large reductions in car transport to hospitals are possible with improved public transport services, car-pooling and encouraging cycling ○ For example, at Addenbrooke's hospital, Cambridge, U.K., by doubling the number of bus services and greatly improving hospital bicycle facilities the proportion of journeys made by car was reduced from 60% in 1999 to 38% in 2006 ○ Social norms and peer influence within the hospital workforce may shape staff decisions regarding how to travel to work • Procurement ○ Several studies have found that procured goods represent by far the largest contributor to healthcare's carbon footprint ○ The research base examining the environmental effects of hospital procurement is far less developed than for hospital architecture and engineering ○ Costs of materials include: the energy, water, petrochemical costs and pollution produced in obtaining raw materials, manufacturing, transportation, use, reuse, maintenance, recycling and waste disposal ○ In the operating theatre, reusable variants of medical devices were found to be less expensive and had lower environmental effects (CO2 emissions, water use, land and water pollution) than the single-use variants for all but the CVC insertion kits ○ The move to single-use items has not been well studied and appears to be driven by other factors beyond infection control practices, such as cost, ease of use, difficulty making some reusable items patient ready again, individual (doctor) preferences and marketing ○ Pharmaceutical companies have rarely engaged with LCA researchers and published in peer-reviewed journals, perhaps due to concerns regarding commercial confidentiality ○ There is renewed interest in return of unused medicines, one study finding that one-fourth of all returned medicines were suitable for reuse ○ The frequency of dialysis has a greater effect upon CO2 emissions than dialysis duration; with the rise of home dialysis delivered more frequently, innovative approaches will be required to prevent the predicted doubling of CO2 emissions per dialysis patient, including methods to reduce consumables and waste disposal • Waste ○ Hospitals in the U.S. alone generate an average of 5,500 tonnes of waste each and every day ○ Avoidance of unnecessary or unproven hospital procedures is likely to have a greater effect than all current hospital recycling initiatives				

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available
	○ Examination of waste disposal shows financial and environmental benefits stemming from treating infectious waste by microwaving rather than autoclaving, lime or incineration ○ Approximately 30% of all hospital waste is paper/cardboard and a similar proportion is plastic, indicating high recycling potentials ○ Approximately 20% of all hospital waste stems from the OR; the associations of anesthetists and surgeons in the U.K. and Ireland have separately issued policy documents to promote consideration of, and research about, the sustainability of anesthesia and cost-effective and sustainable surgery				
Full systematic review (identified as part of evidence searches conducted as part of a related rapid-evidence profile) • Energy-use reductions ○ Building • Non-energy emission solutions ○ Reuse and recycling • Decarbonizing the supply chain ○ Anesthetic gases	Title: Innovations towards achieving environmentally sustainable operating theatres: A systematic review (5) Key findings: • The aim of this systematic review was to assimilate the published studies concerning the sustainability of the perioperative environment, focusing on the impact of implemented interventions, with 34 studies included • Studies were divided into broad themes: recycling and waste management, waste reduction, reuse, reprocessing or life-cycle analysis, energy and resource reduction and anesthetic gases • Over 30% of an entire hospital's waste is generated from surgical provision, of which a significant portion originates from single-use plastic consumables and their associated packaging • Geographical variations in surgical provision can have an impact on the carbon footprint of the same operation, with cataract surgery ranging from six kg CO2eq in India up to 182 kg CO2eq in the U.K. • Recycling and waste reduction ○ Eight studies evaluated interventions that had an impact on recycling and waste management, plus four evaluated waste reduction via streamlining of instrument packs ○ Recycling and waste-reduction interventions can usually be implemented as an extension of national domestic recycling programs ○ Theatre packs were streamlined by reducing the number of rarely used instruments or disposables; this technique led to an annual decrease in waste of 1.48 tonnes • Reuse, reprocessing or life-cycle analysis ○ Eleven studies evaluated single-use disposables with items evaluated including: laparotomy mops, gowns, drapes, plastic drug trays, scissors, central venous catheter insertion kits and airway management tools ○ Overall, the studies identified that reusable items could lead to a substantial improvement in sustainability, with 70% reduction in waste generation, three-fold lower water consumption and 2.5-fold lower energy consumption ○ The destruction of PVC plastics through burning results in increased release of carcinogenic compounds from single-use items when compared to reusable ones ○ The use of reusables is only more sustainable if there is the infrastructure to efficiently reprocess the items; for instance, in Australia reuse had monetary benefits but resulted in a 9% increase in emissions compared to the 84% and 48% decreases seen in the U.K. and U.S.	No	6/9	2020	No

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available

	respectively; this is due largely to Australia still having 75% of its electricity generated from coal, which is a stark contrast to the U.K.'s 1%
	• Energy reduction and minimizing use of natural resources
	  ○ Each of the nine studies that addressed energy and resource reduction evaluated different interventions including water usage during scrubbing, sterilization processes, and different anesthetic machines energy profiles
	  ○ Hospital sterilizers use 40% of their electricity and 20% of their water whilst idle, and turning off idle machines have been shown to save 26% and 13% of a hospital's electricity and water respectively
	  ○ Operating theatre occupancy sensors can result in an electricity saving of one-third
	• Anesthetic agents
	  ○ Four studies looked to reduce impact of anesthetic; desflurane has been identified as having a greater potential impact on global warming than other agents
	  ○ Three of the studies looked at interventions to reduce desflurane usage with a combination of staff education, lower gas flows and promotion of IV anesthesia leading to a 25–55% decrease in its usage
	  ○ Propofol can be a significant source of drug wastage and the intervention of changing the pharmacy dispensing of propofol from 50- or 100-mL bottles to smaller units reduced wastage by 90.4%				

Full systematic review (identified as part of evidence searches conducted as part of a related rapid-evidence profile)
• Investments using a net-zero approach or requirement
• Energy-use reductions
  ○ Building
  ○ Transportation and travel
• Non-energy emission solutions
  ○ Industrial-process improvements
  ○ Reuse and recycling
• Decarbonizing the supply chain
  ○ Anesthetic gases
	Title: Climate-smart actions in the operating theatre for improving sustainability practices: A systematic review (6)
	
	Key findings:
	• The objective of this review was to synthesize available actions that could limit CO2 emission in the OR and their potential benefits upon the environment, whilst preserving quality of care; 38 studies met the inclusion criteria
	• Six core climate-smart actions were identified: 1) waste reduction by segregation; 2) waste reduction by recycling, reuse, and reprocessing; 3) sterilization; 4) anesthesia gas management; and 5) improvement of energy use
	• Improve segregation
	  ○ Nine studies reported that improvement of waste reduction in the OR requires better waste management and segregation; there is high GHG emission during the waste destruction process, which may have a significant impact
	  ○ Waste segregation is the backbone of any climate-smart action in the OR; despite national and local rules for segregation, there is a lack of education to improve and accurately segregate waste
	  ○ A dedicated educational program should be implemented systematically in every institution (or even better, at medical schools) to improve correct segregation and collective awareness of sustainable values
	• Improve waste reduction and recycling
	  ○ Eleven studies addressed waste recycling and reduction
		No	6/9	2021	No

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available
	○ Actions can be oriented to solid waste reduction, OR recyclables and reusables, energy and water reduction, and charitable donations ○ Waste production must be considered all along the patient pathway (before, during, and after the surgery); each one requires different recycling facilities and specific actions ○ Overall, it is important to create educational programs and improve awareness of recycling, and reduce waste production in the OR ○ These actions should be carried out in line with the implementation of dedicated recycling facilities adapted to the patient pathway • Improve reuse and reprocessing ○ Seven studies evaluated reuse of material and equipment ○ Overall, the study found that the implementation of reprocessing of Single Use Medical Devices (SUMDs) as well as reducing their use has an important impact on waste production and consequently on the environment ○ Although SUMDs might have a lot of benefits, clinicians and stakeholders should consider the carbon footprint and should better assess their indication to regulate their use ○ Moreover, manufacturers and institutions should work hand-in-hand, in advance of any contract agreement, to propose dedicated reprocessing pathways to reduce the carbon footprint of waste produced • Sterilization ○ One guideline and five studies evaluated the impact of sterilization ○ In the last decades, hospitals modernized their sterilization process with either ethylene oxide or radiation technologies, opening up the ability to reuse disposables, but data regarding their ecological impact remain weak ○ Efforts to reduce the environmental footprint of reusable items should be directed towards decreasing water and energy consumed in cleaning and sterilization ○ For reusable devices in anesthesiology, washer and H2O2 sterilizer electricity were responsible for, respectively, 86% and 7% of GHG emissions ○ A study comparing the carbon footprint between reusable and disposable ureteroscopes has shown that the main CO2e for reusable ureteroscopes were generated by sterilization (3.95 kg of CO2 per case accounting for 88.4% of total CO2 emission), whereas it was mainly caused by the manufacturing of disposable equipment (3.84 kg of CO2 per case accounting for 86.5% of total CO2 emission) ○ A design permitting low-effort cleaning and sterilization for reusable equipment could be a promising lead to reduce sterilization impact; moreover, reducing the number of devices that need sterilization could also be an efficient way to reduce environmental impact and lower economic costs ○ The impact of sterilization and its GHG emissions are poorly assessed and deserve better attention from researchers • Anesthetic gas management ○ Three studies underlined the impact of anesthetic gases on GHG emissions ○ A prospective study involving three different centres from the U.S. and Europe found that anesthetic gases and energy consumption were the largest sources of GHG emissions in the OR				

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available
	○ Interestingly, the absence of desflurane utilization in the U.K. explains why emissions due to anesthetic gases were 10 times lower in the European department than in the U.S. ○ Despite its fast induction and emergence, desflurane has very high GHG emissions and has been pointed out as the biggest contributor to anesthetic gas emission; for instance, GHG emission of this gas is five-fold higher than that of isoflurane and 20-fold higher than that of sevoflurane ○ Another study found that the removal of desflurane would reduce GHG emissions by 25% during laparoscopic surgery ○ Concerns regarding anesthetic gases should make healthcare workers more careful and propose more alternative anesthetic options such as local, regional or total intravenous anesthesia after consultation with anesthesiologists • Energy efficiency in the OR ○ Fossil fuel combustion is the dominant source of healthcare climate emissions ○ The use of coal, oil and gas to power hospitals, healthcare-related travel and manufacture and transport of healthcare products comprises 84% of all healthcare-related climate emissions across facility operations, supply chain and the broader economy ○ In the OR, heating, ventilation, and air conditioning (HVAC) thermal energy systems comprised 90–99% of overall energy use; this is nearly twice the consumption of other inpatient healthcare facilities ○ The study underlined that occupancy-based ventilation strategies reduced unnecessary airflow to unused space and had the potential for considerable energy saving ○ They calculated that by reducing airflow rates overnight and on weekends, keeping only three of 22 theatres online for emergencies, there was a 50% reduction in HVAC energy consumption ○ A pilot study evaluated a radiofrequency identification system that automatically turned on and adjusted itself according to the number of persons in the OR; the study indicated that the system was working correctly in 98–99% of the cases and could generate 50% energy saving ○ Health Care Without Harms in collaboration with ARUP – an independent firm working across every aspect of today's built environment – is a global road map for healthcare decarbonization, including: power the OR with 100% clean, renewable electricity; invest in zero-emission infrastructure; and transition to zero emission, and sustainable travel and transport by encouraging active travel and public transport for patients and staff wherever feasible ○ Energy consumption is the highest source of GHGs in the OR, but it is also the one where surgeons and the surgical staff have less impact; stakeholders and institution directors must be encouraged to invest in the construction of a sustainable OR				
Full systematic review (identified as part of evidence searches conducted as part of a related rapid-evidence profile) • Energy-use reductions	Title: Greenhouse gas emission savings in relation to telemedicine and associated patient benefits: A systematic review (7) Key findings: • This review investigated GHG emissions related to telemedicine, its potential role in achieving carbon neutrality and its role in determining policy; 31 studies were included (over 57,000 patients) • Few results report the carbon burden associated with telemedicine itself; however, of those that do, this still resulted in a greater than 95% reduction even by the most conservative estimates	No	4/9	2021	No

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available
○ Transportation and travel	• Carbon savings ranged from 0.69 kg CO2e (carbon dioxide equivalent) to 893 kg CO2e per encounter • Distances saved also ranged from 6.1 to 3,386 km • Further analysis of 18 included studies was conducted for cost savings that ranged from 1.73 euros in fuel costs to over $900 USD in travel related expenses • Of the studies that examined the carbon burden, the majority only investigated the running of the equipment; however, one study evaluated the potential life-cycle emissions of the telemedicine equipment arriving at an upper limit of 8.43 kg CO2e • Comparison of life-cycle emissions would result in more accurate data sets				
Full systematic review (identified as part of evidence searches conducted as part of a related rapid-evidence profile) • Investments using a net-zero approach or requirement	Title: BET 1: The clinical impact of policies aimed at reducing the carbon footprint of emergency departments (8) Key findings: • A short-cut systematic review was carried out to establish if strategies to reduce greenhouse gas emissions in the emergency department could succeed while maintaining comparable care standards • Of 2914 papers found in the searches, 40 were selected for full-text review and none of them contained any data or observation of an impact made either clinically or environmentally by an intervention made in an emergency department with the intention of reducing greenhouse gas emissions	No	3/9	2020	
Full systematic review (newly identified) • Energy-use reductions ○ Buildings • Decarbonizing the supply chain ○ Anesthetic gases	Title: The environmental impact of surgery: A systematic review (9) Key findings: • Surgeons should partner with facilities management to make recycling of OR waste and training for proper waste segregation mandatory • Reuse and reduction are the best ways to limit the environmental impact of OR waste • It is important to refine the perception of sources of emissions within specific healthcare fields and introduce emissions-reducing strategies in anaesthesia • Surgeons can build intra- and interinstitutional green teams and collaborate with environmental organizations to learn more strategies for improving sustainability • Potential interventions to reduce other emissions involve improving energy efficiency and replacing fossil fuel energy sources with renewables • Requiring medical equipment manufacturers to publish the metrics of environmental impact could also help eliminate the issue of manufacturers labelling multi-use devices as single use	No	4/10	2020	No
Full systematic review (newly identified) • Investments using a net-zero approach or requirement • Energy-use reductions ○ Buildings	Title: Climate adaptive hospital: A systematic review of determinants and actions (10) Key findings: • In regard to climate change mitigation in hospitals, suggestions include adopting energy efficiency measures and using renewable and clean energy, reducing water consumption, managing health and medical waste, providing facilities to reduce fossil fuel consumption, cooperating in legislation and the implementation of laws supporting the adoption of the green purchasing policy, and providing low-carbon healthcare services	No	5/9	2020	No

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available
○ Transportation and travel • Non-energy emissions solutions ○ Industrial-process improvements ○ Reuse and recycling • Decarbonizing the supply chain ○ Food, catering and nutrition	• Surge capacity components to take into account include measures in Hospital Safety Index, improving the laboratories to identify infectious diseases related to climate change, having an Emergency Response Plan (ERP), employing an Incident Command System (ICS), in-hospital financial proceedings, developing education and research activities like improving the staff's awareness, improving assessment and monitoring capacities, designing an in-hospital rapid alert system, sharing information between hospitals to combat climate change, and supporting local food suppliers for hospital food provision				
Full systematic review (newly identified) • Energy-use reductions ○ Buildings ○ Transportation and travel • Non-energy emissions solutions ○ Industrial-process improvements ○ Reuse and recycling • Decarbonizing the supply chain ○ Anesthetic gases	Title: Environmental sustainability in obstetrics and gynaecology: A systematic review (11) Key findings: • This review found that multiple environmental mitigation strategies can be employed in obstetric and gynecological practices within the operating theatre, delivery room and (outpatient) clinic • Potential improvements include minimizing the use of disposable instruments and materials, replacing disposables with reusable alternatives, improving energy efficiency within operating theatres, switching anaesthetic gases to intravenous anaesthetics, and implementing telemedicine for patients travelling long distances to seek obstetric and gynaecological care	No	7/9	2022	No
Full systematic review (newly identified) • Energy-use reductions ○ Transportation and travel	Title: Does telemedicine reduce the carbon footprint of healthcare? A systematic review (12) Key findings: • The identified papers reported that telemedicine reduces the carbon footprint of healthcare, primarily through the reduction of transport-associated emissions • The carbon footprint savings were dependently related to medical specialty, geography and time • Higher levels of specialization seemed to correspond with greater reductions in travel	No	3/10	2020	No
Full systematic review (newly identified) • Decarbonizing the supply chain ○ Low-carbon inhalers	Title: Impact of asthma inhalers on global climate: A systematic review of their carbon footprint and clinical outcomes in Spain (13) Key findings: • The hypothetical scenario of switching from pressurized metered-dose inhalers (pMDIs) to dry-powder inhalers could reduce the carbon footprint of pMDIs • However, given the inconclusive clinical outcomes, it is challenging to anticipate how switching inhalers for environmental reasons only could affect treatment efficacy	No	6/10	2021	No

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available

Scoping review (newly identified)
• Investments using a net-zero approach or requirement
• Energy-use reductions
  ○ Buildings
  ○ Transportation and travel
• Non-energy emissions solutions
  ○ Industrial-process improvements
  ○ Reuse and recycling
• Decarbonizing the supply chain
  ○ Food, catering and nutrition
	Title: A review of the applicability of current green practices in healthcare facilities (14)
	
	Key findings:
	• Hospitals could reduce their GHG emissions through waste management, energy, water, transportation/travel, hospital design, food optimization, green procurement and behavioural changes
	• Lack of staff awareness and/or knowledge of environmental impacts of healthcare and sustainability were identified as major contributors to negative environmental impact
		No	5/9	2022	No

Full systematic review (newly identified)
• Energy-use reductions
  ○ Buildings
• Decarbonizing the supply chain
  ○ Anesthetic gases
	Title: Implementation approaches to improve environmental sustainability in operating theatres: A systematic review (15)
	
	Key findings:
	• This review found research-to-practice gaps between knowledge of environmental impacts and the application of that evidence to reduce environmental impacts
	• Future research should use implementation research methodology to establish a solid implementation evidence base in influencing the carbon emissions produced by hospitals across all levels
	• Virtual consulting showed a range of minimal to significant quantities of carbon saved depending on the distance that would have been travelled to the healthcare facility by patients
	• Although patient travel is a major consideration, the extent of its contribution varies between inner-city primary care clinics and a specialist hospitals
	• Virtual consulting is not a stand-alone interaction but a part of the wider healthcare system that is less frequently considered to require in-person consultation
		No	5/10	2022	No

Full systematic review (newly identified) • Energy-use reductions ○ Transportation and travel	Title: The role of virtual consulting in developing environmentally sustainable health care: Systematic literature review (16) Key findings: • Virtual consulting showed a range of minimal to significant quantities of carbon saved depending on the distance that would have been travelled to the health care facility by patients • Although patient travel is a major consideration, the extent of its contribution varies between inner-city primary care clinics and a specialist hospitals	No	4/9	2022	No

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available
	• Virtual consulting is not a stand-alone interaction but a part of the wider health care system that is less frequently considered in papers when thinking about or calculating carbon emissions				

Full systematic review (newly identified)
• Energy-use reductions
  ○ Buildings
  ○ Transportation and travel
• Decarbonizing the supply chain
  ○ Low-carbon inhalers
  ○ Anesthetic gases
	Title: Behavioural change interventions encouraging clinicians to reduce carbon emissions in clinical activity: a systematic review (17)
	
	Key findings:
	• The most common techniques to reduce greenhouse gas emissions in healthcare settings were credible source (verbal or visual communication from a credible source in favour of or against the behaviour), social support, salience of consequences, adding objects to the environment (e.g., educational posters displayed in anaesthetic rooms) and prompts or cues
		No	7/10	2022	No

Full systematic review (newly identified)
• Energy-use reductions
  ○ Buildings
• Non-energy emissions solutions
  ○ Industrial-process improvements
  ○ Reuse and recycling
	Title: Interventions for sustainable surgery: A systematic review (18)
	
	Key findings:
	• Reducing and rationalizing materials, the use of reusable equipment and textiles, recycling and correcting waste segregation and anesthetic alternatives were identified as methods to improve sustainability across all stages of the operative pathway
	• The review reported the complexity of implementing sustainable changes to surgical practice given the influence of contextual factors, highlighting the need to critically assess the evidence where interventions are being implemented
	• Despite longstanding existing evidence for successful sustainable interventions, there has not been widespread implementation within surgical departments
		No	6/10	2022	No

Full systematic review (newly identified)
• Energy-use reductions
  ○ Buildings
  ○ Transportation and travel
• Non-energy emissions solutions
  ○ Reuse and recycling
	Title: Considerations for environmental sustainability in clinical radiology and radiotherapy practice: A systematic literature review and recommendations for a greener practice (19)
	
	Key findings:
	• Possible strategies to deliver environmental sustainability (ES) in clinical radiology and radiotherapy (CRR) practice include controlled use of resources, periodic performance auditing, policy formulation and formation of ES working groups, and incorporating ES in clinical radiology and radiography education and training curriculum
	• Opportunities to improve the ES of CRR departments have not been widely prioritized due to lack of discipline-specific ES policies, legislations, education and research
		No	5/9	2023	No

Full systematic review (newly identified)
• Energy-use reductions
  ○ Buildings
  ○ Transportation and travel
	Title: The unintended contribution of clinical microbiology laboratories to climate change and mitigation strategies: a combination of descriptive study, short survey, literature review and opinion (20)
	
	Key findings:
	• Reducing the number of the tests will reduce consumables, one of the most important sources of CO2 emission
		No	1/9	2021	No

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available
	• When choosing manufacturers, the CO2 footprint of instruments and consumables and information regarding waste management should be considered, and manufacturers should make this information available • A solution that has been tested is the delivery of consumables without carboard boxes to reduce the CO2 footprint of transportation				
Full systematic review (newly identified) • Decarbonizing the supply chain ○ Food, catering and nutrition	Title: Integrating sustainable nutrition into health-related institutions: A systematic review of the literature (21) Key findings: • Participants believed sustainable nutrition was an important issue but reported that they needed greater institutional support to enable their involvement, such as updated practice guidelines and action plans issued by practice settings, professional boards, public health institutes or ministries of health • Developing and distributing guidelines that describe the expected practices for different professions and provide indicators to track progress can help the integration of sustainable nutrition • The review identified sharing opportunities, information and teaching tools on sustainable nutrition and providing training as priorities • Information campaigns are recommended to ensure congruence between social expectations and the values and practices promoted by health organizations	No	7/10	2019	No
Full systematic review (newly identified) • Processes, targets, and monitoring and evaluation strategy	Title: A transparency checklist for carbon footprint calculations applied within a systematic review of virtual care interventions (22) Key findings: • Sector-specific guidance would be valuable for carbon footprint (CF) analysis in healthcare and developing such guidance would require collaboration among key stakeholders • For evidence-based decision practice, critically assessing the evidence by evaluating the reporting quality against a benchmark of elements that are to be included in a CF calculation is essential • The transparency catalogue developed in this study can help decision-makers by providing a benchmark for assessing the quality of evidence of CF analyses in healthcare explicitly based on ISO 14067 with GHG protocol and PAS 2050	No	4/9	2019	No
Full systematic review (newly identified) • Non-energy emissions solutions ○ Industrial-process improvements	Title: Environmental impact of flexible cystoscopy: A comparative analysis between carbon footprint of Isiris® single-use cystoscope and reusable flexible cystoscope and a systematic review of literature (23) Key findings: • Both studies found reprocessing was the most significant factor when considering the environmental impact of reusables, but calculations of the emission linked to the reprocessing of the instruments differed greatly	No	3/9	2023	No
Full systematic review (newly identified) • Energy-use reductions	Title: Assessing the carbon footprint of digital health interventions: A scoping review (24) Key findings:	No	3/9	2022	No

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available
○ Buildings ○ Transportation and travel	• The formation of close interdisciplinary collaborations is essential in developing such resources to help healthcare implement environmentally conscious and sustainable digital health solutions • The review found that the development and validation of frameworks, methods and tools for assessing the environmental impact of digital health interventions are early in their development				
Scoping review (identified as part of evidence searches conducted as part of a related rapid-evidence profile) • Energy-use reductions ○ Building • Non-energy emission solutions ○ Reuse and recycling	Title: The carbon footprint of the operating room related to infection prevention measures: A scoping review (25) Key findings: • This review aimed to synthesize evidence on the carbon footprint of commonly used infection-prevention measures in the OR, namely medical devices and instruments, surgical attire and air treatment systems; 57 articles were included • Many infection-prevention measures result in increased emissions • The use of disposable items instead of reusable items generally increases the carbon footprint, depending on sources of electricity • Controversy exists regarding the correlation between air treatment systems, contamination and the incidence of surgical site infections (SSIs) • Evidence suggests that new air treatment systems consume more energy and do not necessarily reduce SSIs compared with conventional systems • Medical devices and instruments ○ Instruments that are going to be reused require mechanical cleaning before decontamination; high-level disinfection is not enough ○ The most effective solution to sterilization problems is the use of disposable instruments; this increased waste production and the use of natural resources ○ U.S. Food and Drug Administration commissions and the U.S. Government Accounting Office have not found evidence to support the opinion that single-use devices reprocessed under approved conditions (including disinfection, cleaning, testing and sterilization) resulted in elevated health risks for patients, although 28% of physicians believe that this would be the case ○ The direct economic savings to hospitals have been estimated to be approximately $20,000 USD per operating room annually ○ Strict regulations (Medical Device Regulations) are a barrier to the reprocessing of single-use devices • Surgical attire ○ Six studies concluded that reusable textiles had substantially better environmental profiles than disposable textiles ○ The use of disposable textiles increased the energy use and carbon footprint by 200–300% ○ An LCA estimated that choosing reusable surgical gowns over disposable gowns reduced energy consumption by 64% and the carbon footprint by 66% ○ Regarding the use of isolation gowns hospital-wide, the carbon footprint was reduced by almost 30% when reusable gowns were used	No	3/9	2021	No

Type of document and mitigation and adaptation strategies addressed	Document title and key findings	Living	Quality (AMSTAR)	Last year literature searched	GRADE profile available
	○ The U.S. Centers for Disease Control and Prevention (CDC) concluded that there are no data suggesting important differences between reusable and disposable gowns and drapes in terms of the prevention of SSIs ○ The use of reusable footwear, surgical gowns and laundered hats will reduce the volume of disposable gowns, caps and overshoes • Heating, ventilating and air conditioning systems ○ Energy conservation efforts should focus on HVAC system management; heating and air conditioning requirements mainly depend on the hospital's geolocation and ambient temperature ○ For instance, one study compared the energy consumption of OR HVAC systems under the different weather conditions in Toronto, Calgary and Sacramento, and found that the use of electricity for cooling was nearly five times higher in Sacramento, while the use of gas for heating was significantly higher in Calgary ○ One way to reduce the environmental impact of the OR is switching off or reducing the HVAC system when the OR is not in use (setbacks), for instance at night or on weekends ○ When the air treatment in ORs is switched off completely for 10 hours, acceptable levels of airborne particles and bacteria are reached within 30 minutes after restarting the system, and this can result in energy savings up to 70% ○ When an OR is not in use, reducing air changes per hour (ACH) could be a beneficial focus for reducing the carbon footprint; in addition, hospitals could save $2,585 CAD per OR per year and $33,600 CAD per year attributable to OR setbacks of the HVAC ○ Radio-frequency identification (RFID) technology is an automatic identification and data capture technology that can be used to offer unique medical staff and patient identification, and react with the HVAC system to reduce energy consumption in the OR ○ A pilot program conducted in Taiwan shows that the RFID system could operate much more efficiently with an estimated 50% reduction in energy consumption compared with the normal ventilation system ○ An advantage of this system is when the OR is needed in an acute setting, the system will start automatically when the first medical staff enters the OR; this way, the indoor air quality of the OR will automatically be ready for surgery to take place				
Protocol for a scoping review (identified as part of evidence searches conducted as part of a related rapid-evidence profile) – strategies not identified	Title: Hospital climate actions and assessment tools: A scoping review protocol (26) Key findings: • This scoping review was planned to summarize the current knowledge about hospital climate action and existing tools to measure progress in this area • This review was planned to include mitigation and adaptation measures, efforts to enhance the adaptive capacity in specific areas, promoting institutional improvement, embracing adaptive management and developing tools	No	N/A	2019	No

Appendix 6: Detailed data extractions from highly relevant single studies about health-system emissions mitigation and adaptation strategies

Mitigation and adaptation strategies addressed	**Document title and key findings** (all identified as part of evidence searches conducted as part of a related rapid-evidence profile)	**Country focus (and year published)**	**Type of study**

• Investments using a net-zero approach or requirement
• Non-energy emission solutions
  ○ Reuse and recycling
	Title: Life cycle environmental emissions and health damages from the Canadian healthcare system: An economic-environmental-epidemiological analysis (27)
	
	Key findings:
	• In Canada, the healthcare sector is responsible for about 4.6% of the nation's total GHG emissions and an estimated 200,000 tonnes of other harmful pollutants; it has been estimated that these emissions result in 23,000 disability-adjusted life years lost annually
	• This documentary analysis was used to investigate the workplace policies that indicated how employees should engage with environmentally responsible practice; the study took place in one large Western Canadian healthcare organization
	• The major themes from this study relate to the resource life-cycle stages: procurement of resources, resource utilization, resource conservation, and waste management
	• The study found that in all the life-cycle stages, the concerns for safety were important determinants of decisions
	• For instance, those in charge of the procurement process are encouraged to find vendors who offer fiscally responsible contracts that deliver safe and effective goods, from what is written in the policies; the procurement process does not seem to consider the emissions produced by the supply chain or if there are other alternative resource sources that have a lower environmental and climate impact
	• Health professionals can lead 'green teams' in their places of work, which aim to reduce waste and global greenhouse gas (GHG) emissions, and they can work with the public to help convey important climate health information and promote planetary health among patients and families
	• Safety concerns were also important in determining actions and behaviours about the use of personal protective equipment and the management of waste
	• Procurement
	  ○ The study did not find current considerations for planetary health within the policies related to the procurement of resources
	  ○ However, the study highlighted an opportunity: healthcare organizations can use market values and purchasing rules to encourage manufacturers and vendors to produce and sell resources that are safe and environmentally clean; a healthcare organization can simultaneously reduce its GHG emissions and environmental impact, and encourage more manufacturers and vendors to develop innovation in this field
	• Resource utilization and conservation
	  ○ Organizational policies that discussed the utilization or conservation of healthcare resources did not mention the climate or environmental impact of these activities
	  ○ An organization could direct employees to reduce unnecessary resource consumption and promote resource conservation whenever possible; this includes outlining appropriate utilization of both workplace supplies and resources such as electricity or thermal power
	• Waste management
	  ○ These policies were the only ones that explicitly prioritized the reduction of healthcare's environmental impact
		Canada (2018)	Modelling

Mitigation and adaptation strategies addressed	**Document title and key findings** (all identified as part of evidence searches conducted as part of a related rapid-evidence profile)	Country focus (and year published)	Type of study
	○ Specifically, these policies aimed to reduce the potential for toxic chemical spills or other scenarios where possible environmental contamination could occur ○ Policies in this approach could encourage the reduction of waste produced in the first place, the assessment and monitoring of organizational waste, and even GHG emissions ○ The study highlighted that one strength of the healthcare sector is its expertise in utilizing monitoring systems, assessments, and tracking methods		
• Decarbonizing the supply chain ○ Anesthetic gases	Title: Greenhouse gas reduction in anaesthesia practice: A departmental environmental strategy (28) Key findings: • This quality-improvement study assessed and evaluated the impact of sustainability interventions on the environmental and financial cost of inhaled anesthetic gas use to guide future initiatives and research in reducing carbon emissions from healthcare practice in the Royal Brisbane and Women's Hospital • Quality-improvement interventions were implemented and overseen by the department director and staff specialists, and no formal staff training was required • Interventions included staff education of desflurane-sparing practices, distribution of posters and progressive removal of desflurane from operating rooms • Researchers obtained information about usage (bottles) and expenditure for desflurane and sevoflurane from January 2016 to December 2021 • The total number of bottles of sevoflurane and desflurane purchased from January 2016 to December 2021 decreased by 34.76% (from 1,991 to 1,299 bottles), the number of desflurane bottles purchased decreased by 95.63% (from 800 to 35 bottles), and the number of sevoflurane bottles purchased increased by 6.13% (from 1,191 to 1,264 bottles) • Combined desflurane and sevoflurane emissions decreased by 87.88% • In 2016, desflurane made up 92.39% of the annual CO2e, which steadily decreased to 33.36% in 2021 • Combined sevoflurane and desflurane usage costs decreased by 58.33% • Applying desflurane-sparing practice can heavily limit anesthetic drug expenditure and contribution to environmental waste	Australia (2022)	Data analytics
• Energy-use reductions ○ Building ○ Transportation • Low- or zero-carbon electricity supply ○ Renewable energy • Electrification and other fuel switching ○ Appliances ○ Vehicles ○ Non-energy emission solutions	Title: Action plan for the mitigation of greenhouse gas emissions in the hospital-based health care of the Hellenic Army (29) Key findings: • This study focused on the carbon footprint of the stationary emission sources of a hospital in Athens, Greece • This study served as a second step in the development of an action plan for the mitigation of greenhouse gas emissions in the hospital-based healthcare of the Hellenic (Greek) Army • A portfolio of energy-saving and emission-reduction actions is proposed and mapped according to their abatement cost and greenhouse gas reduction potential • The highest decrease of GHG emissions is expected to be materialized by the decarbonization of the Greek power sector and the replacement of face-to-face hospital visits by telemedicine, primarily by reducing transport-associated emissions • Electricity	Greece (2022)	Data analytics

Mitigation and adaptation strategies addressed	**Document title and key findings** (all identified as part of evidence searches conducted as part of a related rapid-evidence profile)	Country focus (and year published)	Type of study
	○ Electrification can reduce the hospital's GHG emissions soon, depending on the resources used by the Greek electrical grid operators ○ The increase of renewable energy sources and gas-fired plants, and the shutting down of lignite-fired power plants in the country by 2028, will have a positive impact on reducing indirect GHG emissions in all economic sectors, including the healthcare sector ○ Other low-cost actions such as the "turn the thermostats down and light switches off" policy with posters up in the staff areas and stickers above windows, light switches, air conditioning and electricity-consuming medical equipment can lead to important energy savings and persuade the employees to participate and be environmentally conscious • Transport ○ The study proposed development and broader use of telemedicine, which could play a critical role in the transition to a net carbon-zero healthcare sector ○ The study proposed setting limitations or banning free parking inside the hospital premises and providing incentives for the use of public transport and other more "active" means of transport, such as walking or cycling, and training on eco-driving • Ambulances ○ Use of biofuels in ambulances • Air conditioning systems and refrigerators ○ Gradual replacement of stationary air conditioning systems and freezers with appliances that are more energy efficient • Buildings ○ Hospital buildings should maintain appropriate internal temperatures in areas with different temperature needs, such as in emergency rooms and clinics, in contrast with the waiting rooms and the administration offices ○ The energy team of the hospital should make a chart showing the desired temperatures for each area in the hospital, from the lowest to the top floors of the building ○ Minimize losses by using automatic doors in frequently used hospital entrances		
• Investments using a net-zero approach or requirement	Title: Realist evaluation of the implementation and impact of the NHS carbon reduction strategy in the UK (30) Key findings: • This study aimed to evaluate the extent to which organizational factors facilitate or inhibit the implementation of the National Health Service (NHS) carbon-reduction strategy within acute hospital settings • The 'NHS carbon reduction strategy' was developed in England in 2009, which requires NHS organizations to develop a local carbon-reduction strategy (the Sustainable Development Management Plan) that details different carbon-reduction measures • The study found that carbon-reduction measures were most likely to be implemented if the Trust Board was sufficiently pressured by staff and reputational fears, and the potential impacts of these measures were perceived to align with wider organizational aims • Differences in implementation of carbon-reduction measures across hospital sites were related to logistical factors, accessibility to regional partners and contractual relationships • There were expected carbon, energy and long-term financial savings, with variability in the effectiveness of some carbon-reduction measures post-implementation	U.K. (2021)	Evaluation/ qualitative insights

Mitigation and adaptation strategies addressed	**Document title and key findings** (all identified as part of evidence searches conducted as part of a related rapid-evidence profile)	Country focus (and year published)	Type of study
	• Carbon-reduction measures which were perceived to possess greater co-benefits were more likely to be implemented, with the majority of those implemented belonging to energy, travel and procurement, that is, those mostly associated with external funding and/or partner organizations		

• Energy-use reductions
  ○ Transportation and travel
• Non-energy emission solutions
  ○ Industrial-process improvements
	Title: What is the carbon footprint of primary care practices? A retrospective life-cycle analysis in Switzerland (31)
	
	Key findings:
	• This study aims to quantify the average carbon footprint of a primary-care consultation through a life-cycle assessment, describe differences between primary-care practices (best, worst and average performing) in western Switzerland, and identify opportunities for mitigation
	• The study defined an average practice as consisting of two full-time physicians and two full-time practice assistants, working in a 207 m² premises; together, it provides 6,273 consultations per year, equivalent to 27 consultations per day (considering time off and holidays of staff)
	• The study found that an average medical consultation generated 4.8 kg of CO2eq, and overall an average practice produced 30 tonnes of CO2eq per year, with 45.7% for staff and patient transport and 29.8% for heating
	• Medical consumables produced 5.5% of CO2eq emissions, while in-house laboratory and X-rays contributed less than 1% each
	• Mitigation of a practice's carbon footprint is grounded primarily in transport organization; a dense and local network of primary-care practices could decrease the length of the journey a patient needs to make to see his or her doctor and encourage her or him to come by foot
	• An effective network of public transportation could prompt staff to commute to work rather than use their cars
	• Telehealth could be investigated as a carbon-mitigation option, to cut down on transportation (patient and staff)
		Switzerland (2022)	Data analytics

• Mitigation and adaptation strategies	Title: The carbon footprint of Australian health care (32) Key findings: • This study aimed to measure the carbon footprint of Australia's healthcare system through an observational economic input–output life-cycle assessment • In 2014–15 Australia spent $161.6 billion on healthcare that led to CO2e emissions of about 35.772 (68% CI 25 398–46.146) kilotonnes, which represents 7% of all Australian emissions • The most important emitter sectors within the healthcare were public and private hospitals (44%), pharmaceuticals (18%) and capital expenditure for buildings (8%) • All other healthcare sectors contributed a further 30% of the total carbon footprint, among them, community or public health (6%), general practice (4%), dentistry (3%), aids and appliances (3%), other health practitioners (2%), research (2%), administration (2%) and patient transport services (1%)	Australia (2018)	Data analytics
• Electrification and other fuel switching ○ Vehicles	Title: Can artificial intelligence enable the transition to electric ambulances? (33) Key findings: • The electrification of the transportation sector is seen as a main pathway to reduce CO2 emissions and mitigate the Earth's climate change • Electric vehicles are entering the market fast; however, they have not been used as ambulances yet; the transition to the new type of vehicle is a matter of time	No country focus (2022)	Qualitative insights

Mitigation and adaptation strategies addressed	**Document title and key findings** (all identified as part of evidence searches conducted as part of a related rapid-evidence profile)	Country focus (and year published)	Type of study
	• Based in artificial intelligence, this study proposed a framework for developing online algorithms that schedule the charging of electric ambulances and their assignment to patients • The study concluded that for the electric ambulances to become a reality, apart from the advancements in the engineering domain, the development of fast and efficient online scheduling algorithms accompanied with machine-learning algorithms able to accurately predict future demand and supply is a key point to achieve a gradual transition from conventional ambulances to electric ones		

• Non-energy emission solutions
  ○ Industrial-process improvements
• Decarbonizing the supply chain
  ○ Anesthetic gases
	Title: An estimated carbon footprint of NHS primary dental care within England. How can dentistry be more environmentally sustainable? (34)
	
	Key findings:
	• Public Health England (PHE) commissioned a calculation and analysis of the carbon footprint of key dental procedures
	• The carbon footprint of the NHS dental service is 675 kilotonnes carbon dioxide equivalents (CO2e)
	• Examinations contributed the highest proportion to this footprint (27.1%) followed by scale and polish (13.4%) and amalgam/composite restorations (19.3%)
	• Items with a low individual carbon footprint are radiographs, fluoride varnish and fissure sealants
	• The higher carbon footprints come from more intensive procedures, or procedures that require more than one visit such as crowns or dentures
	• The fictitious example of a patient receiving nitrous oxide by itself would amount to the highest per item carbon footprint of 119 kg CO2e; the concern with nitrous oxide is that it is a toxic greenhouse gas with a high global warming potential; reducing the use of nitrous oxide would be beneficial for the environment, but managing patients with nitrous oxide is often the only alternative to intravenous sedation or general anesthetic, both of which have a higher carbon footprint than nitrous oxide
	• From an emissions perspective, nearly two-thirds (64.5%) of emissions related to travel (staff and patient travel), 19% procurement (the products and services dental clinics buy) and 15.3% related to energy use
		U.K. (2017)	Data analytics

• Mitigation and adaptation strategies	Title: Enhancing the sustainability and climate resiliency of health care facilities: A comparison of initiatives and toolkits (35)
	
	Key findings:
	• This Special Report summarizes several initiatives and compares three toolkits for implementing sustainability and resiliency measures for healthcare facilities: the Canadian Health Care Facility Climate Change Resiliency Toolkit; the U.S. Sustainable and Climate Resilient Health Care Facilities Toolkit; and the PAHO SMART Hospitals Toolkit of the World Health Organization/Pan American Health Organization
	• Canada
	  ○ The Canadian Coalition for Green Health Care, with support from Health Canada and the Nova Scotia Department of Environment, developed the "Health Care Facility Climate Change Resiliency Toolkit"
	  ○ Six facilities in Nova Scotia, Ontario and Manitoba have piloted the toolkit; the first facility was the University Health Network (Toronto)
	  ○ It is expected this toolkit can help the health sector in Canada plan for the challenges posed by climate change; the facilities that have used the toolkit have become important agents of change for reducing fossil fuel
		Americas (2016)	Qualitative insights

Mitigation and adaptation strategies addressed	**Document title and key findings** (all identified as part of evidence searches conducted as part of a related rapid-evidence profile)	Country focus (and year published)	Type of study

	emissions, improving resiliency to extreme weather events, and advocating for public understanding of climate change and health
	• The U.S.
	  ○ The "U.S. Sustainable and Climate Resilient Health Care Facilities Toolkit" was created as an initial component of the 2013 President's Climate Action Plan and the "Enhancing Health Care Resilience for a Changing Climate" effort
	  ○ This toolkit helps health sector officials prepare for climate change impacts based on five elements: climate risks and community vulnerability assessments; land use, building design and regulatory context; infrastructure protection and resiliency planning; essential clinical care service delivery; and environmental protection and ecosystem adaptation
	• PAHO SMART Hospitals Toolkit
	  ○ In addition to a Hospital Safety Index (HIS), the Toolkit contains a Baseline Assessment Tool, a Green Checklist, a Cost Benefit Analysis Tool and a Sustainability Construction Guide Annex
	  ○ In Phase 1 of the project, the pilot facilities – Georgetown Hospital (St. Vincent and the Grenadines) and Pogson Hospital (St. Kitts) – applied the toolkit and retrofitted their facilities with success; they achieved a 50%+ reduction in electrical power consumption and an increase in patients' use of the facilities		

• Energy-use reductions ○ Transportation	Title: Carbon footprint reduction associated with a surgical outreach clinic (36) Key findings: • Outreach clinics may represent tools to assist healthcare systems to decrease greenhouse gas emissions by optimizing patient-related travel, and this study sought to estimate the carbon footprint savings associated with a head and neck surgery outreach clinic • This study was a cross-sectional survey of patient travel patterns to a surgical outreach clinic compared to a regional cancer treatment centre from December 2019 to February 2020; 113 patients were included for analysis • The study found that most patients (85.8%) used their own personal vehicle to travel to the outreach clinic • The median distance to the clinic and regional centre were 29 km (IQR 6.0–51.9) and 327 km (IQR 309.0–337.0) respectively • The mean carbon-emission reduction per person was therefore 117,495.4 g (SD: 29,040.0) to 143,570.9 g (SD: 40,236.0); this represents up to 2.5% of an average individual's yearly carbon footprint • There is a substantial carbon footprint related to traveling to healthcare appointments, and this study has shown carbon emissions may be reduced by providing outreach clinics when healthcare is regionalized	Canada (2021)	Data analytics
• Decarbonizing the supply chain ○ Low-carbon inhalers	Title: The carbon footprint of respiratory treatments in Europe and Canada: An observational study from the CARBON programme (37) Key findings: • As part of the CARBON program, the SABA CARBON Europe and Canada observational cohort study quantified the carbon footprint associated with the use of both reliever and controller inhalers in 20 European countries and in Canada, and short-acting β2-agonists (SABAs) overuse (prescription/dispensing of three or more canisters per year) in five European countries and two Canadian provinces (Alberta and Nova Scotia) from the SABINA program • Overall, the study found that suboptimal respiratory treatment, in the form of high SABAs use across Europe and Canada, remains widespread, representing approximately two-thirds of total GHG emissions	Canada and Europe (2022)	Data analytics

Mitigation and adaptation strategies addressed	**Document title and key findings** (all identified as part of evidence searches conducted as part of a related rapid-evidence profile)	Country focus (and year published)	Type of study
	• Authors suggested that these findings highlight the importance of assessing the contribution of SABAs to the carbon footprint of respiratory treatment, which in many countries were commonly used and administered by metered-dose inhalers, thereby explaining higher GHG emissions associated with SABA versus controller inhaler use		

• Electrification and other fuel switching
  ○ Vehicles
	Title: The carbon footprint of Australian ambulance operations (38)
	
	Key findings:
	• This was a two-phase study of operational and financial data from a convenience sample of Australian ambulance operations to inventory their energy consumption and greenhouse gas emissions for one year; state- and territory-based ambulance systems serving 58% of Australia's population and performing 59% of Australia's ambulance responses provided data for the study
	• The study found that emissions for the participating systems totalled 67.390 metric tonnes of carbon dioxide equivalents
	  ○ For ground ambulance operations, emissions averaged 22 kg of carbon dioxide equivalents per ambulance response, 30 kg of carbon dioxide equivalents per patient transport and 3 kg of carbon dioxide equivalents per capita
	  ○ Vehicle fuels accounted for 58% of the emissions from ground ambulance operations, with the remainder primarily attributable to electricity consumption
	  ○ Emissions from air ambulance transport were nearly 200 times those for ground ambulance transport
	• Potential strategies for reducing ambulance-system energy consumption and GHG emissions include reducing unnecessary ambulance responses and ambulance transports, developing flexible response time policies, reducing driving speeds when transporting stable patients without life-threatening conditions, reduced ambulance idling at emergency scenes and receiving hospitals, the use of hybrid vehicles for administrative and support vehicle fleets, or the use of biodiesel for ambulances
	• However, none of these proposed strategies has been empirically evaluated; their actual impact on energy consumption and emissions, as well as patient outcomes, remains to be determined
		Australia (2012)	Data analytics

• Decarbonizing the supply chain
  ○ Food, catering and nutrition
	Title: Hospital food waste and environmental and economic indicators – A Portuguese case study (39)
	
	Key findings:
	• This study presents a comprehensive characterization of plate waste (food served but not eaten) at an acute-care hospital in Portugal, and elaborates on possible waste-reduction measures
	• The study reported that on average each patient throws away 953 g of food each day, representing 35% of the food served; this equates to 8.7 thousand tonnes of food waste being thrown away each year at hospitals across Portugal
	  ○ These tonnes of food transformed into waste represent economic losses and environmental impacts, being estimated that 16.4 thousand tonnes of CO2 (equivalent) and 35.3 million euros are the annual national indicators in Portugal
	  ○ This means that 0.5% of the Portuguese National Health budget gets thrown away as food waste
	• Given the magnitude of the food problem five measures were suggested to reduce food waste:
	  ○ bread on demand
	  ○ switching from a plated to a bulk system for meal delivery
	  ○ choice of portion size
	  ○ increase menu options
		Portugal (2015)	Data analytics

Mitigation and adaptation strategies addressed	**Document title and key findings** (all identified as part of evidence searches conducted as part of a related rapid-evidence profile)	Country focus (and year published)	Type of study
	○ prompt update of empty beds to detect and record last-minute changes to the number of meals required		
• Non-energy emission solutions ○ Industrial-process improvements	Title: Environmental sustainability and the carbon emissions of pharmaceuticals (40) Key findings: • This article focused on the emissions of pharmaceuticals, since the carbon of pharmaceuticals are relatively understudied despite the fact that globally, the pharmaceutical industry's carbon emissions are more than 50% higher than the automotive sector • In the U.K. (2007) it was estimated that pharmaceuticals contribute nearly a quarter of the CO2 emitted each year by the health sector (2007); in the U.S. (2009) it was estimated as 14% • Factors that contribute to pharmaceutical carbon emissions include over prescription, pharmaceutical waste, antibiotic resistance, routine prescriptions, non-adherence, drug dependency, lifestyle prescriptions, and drugs given due to a lack of preventive healthcare • 'Greening' the life cycle of pharmaceuticals requires the support of chemists, medical engineers, medical manufacturers, product designers and other supportive stakeholders • Carbon reduction of pharmaceuticals can lead to cleaner, more sustainable healthcare	U.S. (2022)	Qualitative insights
• Non-energy emission solutions ○ Industrial-process improvements	Title: The carbon footprint of hospital diagnostic imaging in Australia (41) Key findings: • This study performed a prospective life-cycle assessment at two Australian university-affiliated health services of five imaging modalities: chest X-ray (CXR), mobile chest X-ray (MCXR), computerized tomography (CT), magnetic resonance imaging (MRI) and ultrasound (US) • The study found a mean CO2e emissions of 17.5 kg/scan for MRI; 9.2 kg/scan for CT; 0.8 kg/scan for CXR; 0.5 kg/scan for MCXR; and 0.5 kg/scan for US • Authors recommend that clinicians and administrators reduce carbon emissions from diagnostic imaging by: ○ reducing the ordering of unnecessary imaging ○ when clinically appropriate, ordering low-impact imaging (X-ray and US) instead of MRI and CT ○ whenever possible, scanners should be turned off to reduce emissions from standby power ○ ensuring high utilization rates for scanners reducing standby times	Australia (2022)	Modelling
• Decarbonizing the supply chain ○ Low-carbon inhalers	Title: Impact of inhalers used in the treatment of respiratory diseases on global warming (42) Key findings: • This article presented indicators of the carbon footprint, European and Polish legal regulations on the reduction of greenhouse gases, a short review of inhalers and inhalation drugs based on the example of the Polish market, results of studies on the carbon footprint of selected inhalers, and methods of reducing the negative impact of inhalers on the environment • Methods of reducing the carbon footprint of inhalers: ○ reducing the use of short acting beta-2 agonist (SABA) "on demand" in all types of inhalers by improving asthma and COPD control (physician, patient) ○ optimal use of the inhalation chamber, usually associated with the improvement of the clinical efficacy of pressurized metered-dose inhaler (pMDI) drugs (physician, patient) ○ using inhalers for the last dose and not wasting doses by releasing the drug into the atmosphere (patient)	Europe and Poland (2021)	Data analytics

Mitigation and adaptation strategies addressed	**Document title and key findings** (all identified as part of evidence searches conducted as part of a related rapid-evidence profile)	Country focus (and year published)	Type of study
	○ introduction of pMDI with new propellants with lower global warming potential (GWP) values, for example, hydrofluoroalkane (HFA) 152a (manufacturer, payer, physician) ○ rational replacement of pMDI by dry-powder inhaler (DPI) or metered-dose liquid inhaler MDLI (doctor) ○ reducing the number of inhalers in each patient through the wider use of drugs combined in one inhaler and the introduction of new two- or three-component formulations (manufacturer, physician, payer) ○ creating DPI and MDLI inhalers with replaceable cartridges extending the time of using the inhaler (manufacturer) ○ using DPI capsule for a larger number of doses, which requires actions that improve the inhalers (manufacturer) ○ promoting the recycling of all inhalers (manufacturer, pharmacy, patient)		

Appendix 7: Summary of what is known from a jurisdictional scan of Canadian provinces and territories about strategic partnerships and funder networks established to accelerate progress towards net-zero emissions in health systems

Jurisdiction	Strategic partnerships and/or funder networks identified	Types of strategies that are the focus of the partnership or network	Lessons learned from the partnership/network

Federal/pan-Canadian	**Strategic Partnership**
	• The Canadian Coalition for Green Health Care builds capacities across individuals and organizations engaged in developing environmentally sustainable, net-zero and climate-resilient health systems
	  ○ The elements of the ideal green community include reducing reliance on fossil fuels for energy production, changing transportation practices, engaging in sustainable procurement, and producing green scorecards and stewardship guidebooks for hospitals and long-term care facilities
		• Mitigation and adaptation strategies
		  ○ Energy-use reductions
		  ▪ Buildings
		  ▪ Energy production
		  ▪ Industry partners (e.g., IT partners)
		  ▪ Transportation and travel
		  ○ Electrification and other fuel switching
		  ▪ Supporting infrastructure
		  ▪ Vehicles
		  ○ Non-energy emission solutions
		  ▪ Reuse and recycling
		  ○ Decarbonizing the supply chain
		  ▪ Food, catering and nutrition
			• No lessons learned identified

	Strategic Partnership
	• CASCADES is an initiative funded by the University of Toronto Collaborative Centre for Climate, Health & Sustainable Care, the Healthy Populations Institute at Dalhousie University, the Planetary Healthcare Lab at the University of British Columbia, and the Canadian Coalition for Green Health Care, as well as Environment and Climate Change Canada
	  ○ The mission of CASCADES includes achieving a net-zero health system that removes climate-altering greenhouse gases from health products, services, infrastructure, and supply chains
	  ○ CASCADES focuses on leveraging community expertise to build implementation resources, training, and collaboration to improve pan-Canadian coordination, while focusing on the following 10 priority areas:
	  ▪ pharmacy and prescribing
	  ▪ primary and community care
	  ▪ perioperative care
	  ▪ clinical specialties
	  ▪ improving health
	  ▪ quality improvement and patient safety
	  ▪ strategy and performance
	  ▪ measurement
		• Mitigation and adaptation strategies
		  ○ Energy-use reductions
		  ▪ Buildings
		  ▪ Transportation and travel
		  ○ Non-energy emission solutions
		  ▪ Reuse and recycling
		  ○ Decarbonizing the supply chain
		  ▪ Food, catering and nutrition
		  ▪ Low-carbon inhalers
			• Creating business cases and 'playbooks' for each of the priority areas can help encourage and facilitate organizations' efforts towards net-zero practices and infrastructure

Jurisdiction	Strategic partnerships and/or funder networks identified	Types of strategies that are the focus of the partnership or network	Lessons learned from the partnership/network
	▪ procurement ▪ operations and infrastructure o CASCADES is a partner in the Réseau d'action pour la santé durable du Québec, and partners with the Canadian College of Health Leaders to offer health leaders in Canada an avenue to build knowledge, skills and networks		
	Strategic Partnership • Nourish Leadership works to engage healthcare leaders to leverage food to ensure health systems can be more preventative, equitable, and sustainable o These efforts include changing hospital menus, food service operations and procurement to help decarbonize supply chains, modelling sustainable diets in healthcare facilities to influence population dietary shifts, and reduce food waste to reduce healthcare's carbon footprint	• Mitigation and adaptation strategies o Non-energy emission solutions ▪ Reuse and recycling o Decarbonizing the supply chain ▪ Food, catering and nutrition	• Food is medicine, and ensuring that food used in healthcare is sustainably sourced can help healthcare systems and broader society develop food habits that are healthy for individuals and the environment
	Funder Network • The Clean Economy Fund works to connect the philanthropic community with initiatives working towards net-zero goals	• Mitigation and adaptation strategies o Investments using a net-zero approach or requirement	• No lessons learned identified
	Funder Network • Environment Funders Canada is a national network that brings together philanthropic foundations and other organizations – including healthcare organizations – that support efforts to build a more sustainable world o They emphasize shared learning, personal development opportunities, best practice development, and various types of networking to build strong networks to increase effectiveness and generate innovative approaches	• Mitigation and adaptation strategies o Investments using a net-zero approach or requirement	• No lessons learned identified
	Funder Network • The McConnell Foundation's Climate Action Plan commits to a net-zero portfolio by 2050	• Mitigation and adaptation strategies o Investments using a net-zero approach or requirement	• No lessons learned identified
B.C.	**Strategic Partnership** • GreenCare is a healthcare network for environmentally sustainable and resilient care that unites efforts across health system actors, including by o focusing on reducing carbon footprint and increasing energy efficiency and reducing reliance on fossil fuels o developing plant-forward, local, culturally relevant and equitable food services o minimizing water consumption and waste o increase access to and use of transportation modes that reduce negative environmental impacts	• Mitigation and adaptation strategies o Energy-use reductions ▪ Energy production ▪ Transportation and travel o Electrification and other fuel switching ▪ Supporting infrastructure o Decarbonizing the supply chain ▪ Food, catering and nutrition	• No lessons learned identified
A.B.	• No strategic partnerships identified • No funder networks identified		
S.K.	• No strategic partnerships identified • No funder networks identified		
M.B.	• No strategic partnerships identified • No funder networks identified		

Jurisdiction	Strategic partnerships and/or funder networks identified	Types of strategies that are the focus of the partnership or network	Lessons learned from the partnership/network
O.N.	**Strategic Partnership** • The Partnerships for Environmental Action by Clinicians and Communities for Healthcare Facilities (PEACH) Health Ontario is a provincial initiative that is committed to supporting healthcare professionals in taking climate action within their own healthcare sites • The guiding principles of this partnership rely on supporting climate action leaders, respecting varying voices of individuals from 'all walks of life', incorporating social justice and equitable practices, fostering education and knowledge exchange, and promoting immediate action and collaboration	• Mitigation and adaptation strategies o Energy-use reductions ▪ Buildings ▪ Energy production ▪ Transportation and travel o Electrification and other fuel switching ▪ Supporting infrastructure ▪ Vehicles o Non-energy emission solutions ▪ Reuse and recycling o Decarbonizing the supply chain ▪ Food, catering and nutrition ▪ Low-carbon inhalers ▪ Anesthetic gases	• The partnership's web page features key insights and wisdom from experts on climate change and sustainability • Key lessons include the success of green initiatives in operating rooms, and the implementation of green spaces to support physical and mental health
	Strategic Partnership • A partnership operated by the Energy & Environment Department at University Health Network (UHN) in Toronto, Talkin' Trash with UHN, is focused on leading the charge for a greener future within the healthcare sector in the province • This partnership is focused on climate actions related to energy, water, waste, transportation, and garden	• Mitigation and adaptation strategies o Energy-use reductions ▪ Energy production ▪ Land use ▪ Transportation and travel o Non-energy emission solutions ▪ Reuse and recycling	• This partnership features a 'Green Team' and a 'Green Wall of Fame' that highlights the efforts of sustainably minded staff who have helped to make green changes within their departments • Active efforts from this initiative include reprocessing single-use medical devices, a medication ampules recycling program, and *Operation Green*, which is a program to collect surplus medical supplies and donate them to global communities in need (e.g., Turkey, Ukraine, Haiti)
	Strategic Partnership • The London Health Sciences Centre (LHSC) Green Team is operated by a group of healthcare professionals aiming to make the practices at LHSC more environmentally friendly • This partnership aims to address environmental concerns through sustainability initiatives, such as clean energy, water consumption, waste disposal, and transportation; this team is focused on strengthening the culture of sustainability within the hospital site and in their own communities	• Mitigation and adaptation strategies o Energy-use reductions ▪ Energy production ▪ Transportation and travel o Non-energy emission solutions ▪ Reuse and recycling	• The LHSC Green Team's web page will provide key knowledge on environmental issues and highlight projects that departments have been undertaking to improve sustainability efforts

Jurisdiction	Strategic partnerships and/or funder networks identified	Types of strategies that are the focus of the partnership or network	Lessons learned from the partnership/network

	Strategic Partnership
	• Foundation House, is a workspace and convening hub for the philanthropic and not-for-profit communities in Toronto; it features 10 organizations that are focused on changing the way these two sectors interact and work together
	  ○ Environment Funders Canada is one of the 'tenants' of Foundation House
	• Foundation House is committed to the promotion of collaboration as a tool to decision-making efforts, and focusing on remaining intentional as it leads to benefit to civil society
		• Mitigation and adaptation strategies
		  ○ Energy-use reductions
		  ▪ Buildings
			• Foundation House has published a list of 20 key lessons/learnings that it wishes to highlight from its experience thus far
			• The themes of these key learnings are centred around shared decision-making, the importance of stakeholders/partners/ relationships, identifying realistic goals/vision, among many more

	Strategic Partnership • The Centre for Sustainable Health Systems merged with a multi-faculty unit at the University of Toronto, and is now part of the Collaborative Centre for Climate, Health & Sustainable Care • The strategic planning process for the new unit started in January 2024; however, this partnership is a collaborative initiative of four founding health sciences faculties at the University of Toronto (e.g., public health, medicine, nursing, and pharmacy) • This Centre focuses on leveraging the strengths of the university in research and education to develop the evidence and capacity needed to transition to a sustainable health system • In 2021, the Centre was awarded $6 million to lead national initiatives for climate action and awareness in healthcare	• Mitigation and adaptation strategies	• The Centre initiated a Sustainable Health System Community of Practice in September 2020, which features 14 academic hospital and seven health science faculties at the University of Toronto; this community of practices helps to work together to provide evidence, share ideas/lessons, and promote leadership and advocacy
	Funder Network • University of Toronto Connaught Global Challenge Fund has funded the Research Capacity for a Climate Positive Health System: The International Research Network for Climate Positive Care (IRNCPC) • The strategic themes include changing the role of healthcare to deliver a more sustainable medical ecosystem, which can include reshaping the environment of care, generating evidence for sustainable system innovation, and developing training pathways for interdisciplinary research on climate positive health systems • The focus of the initiative will be shifted as of 2022 to facilitate research networking, team formation, and exploring further funding opportunities	• Mitigation and adaptation strategies ○ Investments using a net-zero approach or requirement	• No lessons learned were identified
Q.C.	**Strategic Partnership** • The Action Network for Sustainable Health of Quebec (Le réseau d'action pour la santé durable du Québec) (RASDQ) connects health and social service organizations in the provinces together to promote the health of the population ○ The focus of this network is to prevent and adapt to the climate crisis, support sustainable communities by investing in public health, and implement a sustainable health system (by aiming for carbon neutrality)	• Mitigation and adaptation strategies	• No lessons learned were identified
	Strategic Partnership	• Mitigation and adaptation strategies	• No lessons learned were identified

Jurisdiction	Strategic partnerships and/or funder networks identified	Types of strategies that are the focus of the partnership or network	Lessons learned from the partnership/network
	• Philanthropy House is an innovative space, inspired by the Foundation House in Toronto, that serves as an activity centre for both individuals and organizations driving change in their communities ○ Greater Montreal Climate Fund and Partenariat Climat Montréal are core partners of the Philanthropy House • Philanthropy House is centred on generating action-oriented ideas that leverage impact to improve communities; collaboration serves as a strategic pillar, whereby the sharing of workplaces can aid organizations in increasing their knowledge, discover innovative solutions, convene stakeholders, and expand their connections		

	Strategic Partnership
	• Ouranos is a leading Quebec-based organization that supports the province in adapting to climate change; it does this by ensuring strong ties and cohesion between the scientific community and adaptation stakeholders
	• The approach that Ouranos uses is a shared leadership strategy, whereby the research environment enables growth and opportunities to actively contribute to the solution
	• Ouranos specializes in co-financing of interdisciplinary and multi-institutional projects that promote climate action, supporting climate scenarios and services in the province and at large and producing regional climate simulations using the Canadian Regional Climate Model 5
		• Mitigation and adaptation strategies	• The context in which the consortium was first established differs from that of the current day as it is now recognized that climate change adaptation is critical for the success and resiliency of Quebec as a province
			  ○ A growing demand for adaptation-related information and services
			  ○ Ouranos needs to serve a stronger role in developing and consolidating climate change expertise, promote integration for more robust answers, and mobilize knowledge for societal benefit

	Funder Network
	• In Quebec, the Trottier Family Foundation (Fondation Familiale Trottier), works with organizations to advance scientific inquiry, promote education, foster health, protect the environment, and mitigate climate change
	  ○ With the creation of the Montreal Climate Partnership, the Trottier Family Foundation now has a focus on climate issues
	• The Trottier Family Foundation has adopted a two-fold approach:
	  ○ 'reactive philanthropy,' whereby partners solicit the Foundation for support; and
	  ○ 'proactive philanthropy,' whereby the foundation's funds are used as catalytical capital to seek out partners
	• The Trottier Family Foundation's allocation of $10 million is set to reduce greenhouse gas emissions and support Quebec's healthcare system in becoming more resilient by decarbonizing healthcare facilities, and integrating climate action into the Greater Montreal health network
	  ○ reduction of greenhouse gas emissions connected to aesthetic gases at McGill University Health Centre
		• Mitigation and adaptation strategies
		  ○ Investments using a net-zero approach or requirement
			• No lessons learned were identified

Jurisdiction	Strategic partnerships and/or funder networks identified	Types of strategies that are the focus of the partnership or network	Lessons learned from the partnership/network
	○ raising awareness among public actors ○ developing solutions to integrate net-zero objectives within the health networks		
N.B.	**Strategic Partnership** • Since 2018, ARC Clean Technology (ARC) and New Brunswick (NB) Power have worked together on developing the ARC-100, a 100-megawatt advanced sodium-cooled fast reactor, at NB Power's existing Point Lepreau Nuclear Generation Station that is anticipated to provide clean energy to the province by 2030 ○ Important applications of the ARC-100 include the decarbonization of heavy industry and the creation of live-saving medical isotopes • Similarly, Moltex Energy has partnered with NB Power to develop a modular reactor fuelled by recycled nuclear waste that will provide clean, reliable energy to New Brunswick once operational in the 2030s	• Mitigation and adaptation strategies ○ Low- or zero-carbon electricity supply and purchasing ▪ Nuclear power ▪ Renewable energy	• No lessons learned were identified
N.S.	**Funder Network** • In November 2022, the Environment Goals and Climate Change Reduction Act was amended to create an output-based pricing system (OBPS) to put a price on greenhouse gas emissions from large emitters	• Mitigation and adaptation strategies ○ Investments using a net-zero approach or requirement	• No lessons learned were identified
P.E.I.	• No strategic partnerships identified • No funder networks identified		
N.L.	**Strategic Partnership** • Completed in November 2023, the new environmentally friendly Western Memorial Regional Hospital was constructed through the public private partnership of Corner Brook Health Partnership (CBHP) ○ With a contract value of $750 million, CBHP was selected to design, build, finance and manage the new acute care hospital in Corner Brook	• Mitigation and adaptation strategies ○ Energy-use reductions ○ Buildings	• No lessons learned were identified
Y.K.	• No strategic partnerships identified • No funder networks identified		
N.T.	• No strategic partnerships identified • No funder networks identified		
N.U.	• No strategic partnerships identified • No funder networks identified		

Appendix 8: Summary of what is known from an international jurisdictional scan about strategic partnerships and funder networks established to accelerate progress towards net-zero emissions in health systems

Jurisdiction	Core features of identified strategic partnerships and/or funder networks	Types of strategies that are the focus of the partnership or network	Lessons learned from the partnership/network

International	**Strategic Partnership**
	• Health Care Without Harm provides guidance and resources on decarbonization and bolstering resilient health systems for health ministries, private health institutions and health professionals globally
	  ○ Health Care Without Harm is a healthcare partner of the United Nations backed global campaign Race to Zero, which includes more than 70 healthcare institutions representing the interests of over 14,000 hospitals and health centres across 26 countries working towards a zero-carbon world
	  ○ Health Care Without Harm's road map towards zero emissions includes three pathways (facilities and operations, supply chain and wider economy) and seven actions: 1) renewable energy, 2) zero-emissions buildings, 3) zero emissions transport, 4) healthy sustainable (food), 5) low carbon pharma, 6) circular health and 7) system effectiveness
	  ○ Recommended interventions include efforts to maximize energy efficiency, switching to renewable electricity, employ sustainable/circular procurement, purchasing policies and waste management, optimizing building design and staff zero-carbon competencies, transition to zero emission fleet vehicles and infrastructure, provide healthy and sustainably grown food, and incentivize and produce low-carbon pharmaceuticals
		• Mitigation and adaptation strategies
		  ○ Energy-use reductions
		  ▪ Buildings
		  ▪ Energy production
		  ▪ Transportation and travel
		  ○ Low- or zero-carbon electricity supply and purchasing
		  ▪ Renewable energy
		  ○ Electrification and other fuel switching
		  ▪ Supporting infrastructure
		  ▪ Vehicles
		  ○ Non-energy emission solutions
		  ▪ Reuse and recycling
		  ○ Decarbonizing the supply chain
		  ▪ Food, catering and nutrition
		  ▪ Low-carbon inhalers
		  ▪ Anesthetic gases
			• No lessons learned identified

	Strategic Partnership
	• The World Health Organization's guidance on climate-resilient and environmentally sustainable healthcare facilities aims to enhance the capacity of healthcare facilities to become more climate resilient and environmentally sustainable by optimizing the use of resources and minimizing the release of waste
	  ○ Proposed interventions include: improving awareness and competencies of healthcare staff; implementing monitoring and assessment protocols for waste management; ensuring building characteristics, energy efficiency, transportation, food and pharmaceuticals reduce emissions as much as possible; and constructing and retrofitting healthcare facilities to ensure environmental sustainability
	  ○ Itemized checklists for each category of intervention provide detailed breakdowns of important considerations for healthcare facilities and provide a way of tracking progress according to the action level of each item
		• Mitigation and adaptation strategies
		  ○ Energy-use reductions
		  ▪ Buildings
		  ▪ Energy production
		  ▪ Transportation and travel
		  ○ Non-energy emission solutions
		  ▪ Reuse and recycling
		  ○ Decarbonizing the supply chain
		  ▪ Food, catering and nutrition
			• Establishing a shared framework and checklists to guide net-zero initiatives can contribute to better coordination and more comprehensive action

	Strategic Partnership
	• The World Bank's Climate-smart health care: Low-carbon and resilience strategies for the health outlines 10 mitigation strategies along with corresponding actions, emissions impact, and health benefits for each: improving energy supply and distribution efficiency; on-site renewable energy sources; reduced-energy devices; passive cooling, heating and ventilation strategies; facility wastewater and solid waste management; reduced greenhouse gas emissions from anaesthesia gas use; reduced procurement carbon footprint;
		• Mitigation and adaptation strategies
		  ○ Investments using a net-zero approach or requirement
		  ○ Energy-use reductions
		  ▪ Buildings
		  ▪ Energy production
		  ▪ Transportation and travel
			• No lessons learned identified

Jurisdiction	Core features of identified strategic partnerships and/or funder networks	Types of strategies that are the focus of the partnership or network	Lessons learned from the partnership/network
	telehealth/telemedicine; public transport options; and conserving and maintaining water resources	○ Low- or zero-carbon electricity supply and purchasing ▪ Renewable energy ○ Non-energy emission solutions ▪ Reuse and recycling ○ Decarbonizing the supply chain ▪ Anesthetic gases	
	Strategic Partnership • During the 26th United Nations Climate Change Conference (COP26), the U.K. Government, World Health Organization (WHO), Health Without Harm and the UNFCCC Climate Champions led the promotion of the COP26 Health Programme, which commits to advancing health initiatives on climate resilient and low carbon, sustainable health systems ○ The programme commits to advancing climate resilient health systems by developing national health adaptation plans and sustainable low carbon health systems by setting targets for achieving net-zero emissions and developing an action plan or roadmap to develop sustainable low carbon health systems (including supply chains) ○ More than 70 countries committed at the level of minister of health to strengthen climate resilience and lower the emissions of health systems ○ The Alliance for Transformative Action on Climate Change and Health (ATACH) is a WHO-led mechanism supporting delivery on the COP26 health commitments, acting as a platform for coordination, knowledge and best practice exchange, networks and access to support, monitoring global progress, and tackling common challenges	• Mitigation and adaptation strategies	• Strategic partnerships can benefit from coordinating bodies that act as a mechanism for system learning and best practice exchanges, networking and support, and ongoing monitoring as partners work towards shared goals and navigate common challenges
Australia	**Strategic Partnership** • The Monash Sustainable Development Institute (MSDI) leverages collaboration and co-design across government, industry and communities to advance sustainable healthcare ○ MSDI conducts evidence reviews and syntheses and applied research, and facilitates capacity building through the Sustainable Healthcare in Practice micro-credential 10-week course, among other courses ○ MSDI's initiatives Climateworks Centre and BehaviourWorks Australia work with organizations and government to provide evidence, build capacity and shape policy design across seven systems of work contributing to net-zero: ▪ food, land and ocean systems ▪ cities ▪ industry ▪ energy ▪ sustainable corporates ▪ sustainable finance ▪ sustainable economies	• Mitigation and adaptation strategies ○ Energy-use reductions ▪ Buildings ▪ Energy production ▪ Industry partners (e.g., IT partners) ▪ Land use ▪ Transportation and travel ○ Low- or zero-carbon electricity supply and purchasing ▪ Renewable energy ○ Decarbonizing the supply chain ▪ Food, catering and nutrition ▪ Low-carbon inhalers ▪ Anesthetic gases	• No lessons learned identified
	Strategic Partnership • The government of New South Wales provides guidance for local health districts, specialty networks and health organizations to work towards net-zero, which includes developing a	• Mitigation and adaptation strategies ○ Energy-use reductions ▪ Transportation and travel	• No lessons learned identified

Jurisdiction	Core features of identified strategic partnerships and/or funder networks	Types of strategies that are the focus of the partnership or network	Lessons learned from the partnership/network
	plan for prescribing lower carbon inhalers, reducing desflurane to <10% of its total volatile anaesthetic gas use by volume, purchase and lease low or zero-emissions vehicles, and conducting 25+% of all outpatient activity remotely	○ Electrification and other fuel switching ▪ Vehicles ○ Decarbonizing the supply chain ▪ Low-carbon inhalers ▪ Anesthetic gases	
Denmark	**Strategic Partnership** • As part of Denmark's Climate Action Strategy that works towards reducing greenhouse gas emissions by 70% from 1990 levels to 2030, a collaboration between hospitals and medical technology manufacturers is evaluating the feasibility of recycling used blood collection tubes to reduce medical waste	• Mitigation and adaptation strategies ○ Energy-use reductions ▪ Industry partners (e.g., IT partners) ○ Non-energy emission solutions ▪ Reuse and recycling ○ Decarbonizing the supply chain	• No lessons learned identified
New Zealand	**Strategic Partnership** • New Zealand's guide on Sustainability and the Health Sector published by the Ministry of Health encourages actors across the health sector to advance sustainable practices in six areas: waste, transportation, procurement, energy, food and building design ○ These include efforts to procure environmentally friendly fleet vehicles, incentivizing remote care, waste reduction (including from recycling efforts, reducing emissions from anaesthetic gases, and optimizing building design and food supply chains to reduce carbon emissions)	• Mitigation and adaptation strategies ○ Energy-use reductions ▪ Buildings ▪ Transportation and travel ○ Electrification and other fuel switching ▪ Vehicles ○ Non-energy emission solutions ▪ Reuse and recycling ○ Decarbonizing the supply chain ▪ Food, catering and nutrition ▪ Anesthetic gases	• No lessons learned identified
Norway	• No strategic partnerships identified • No funder networks identified		
Singapore	**Strategic Partnership** • While no strategic partnerships focused solely on advancing efforts to achieve net-zero health systems in Singapore were identified, the Singapore Green Building Council is a broad-base, active network focused on sustainability efforts in the country ○ MOH Holdings (MOHH), a holding company of Singapore's public healthcare, has recently signed up to be a corporate member of this Council • The key focus areas of the Singapore Green Building Council include: ○ utilizing public education to profile Singapore as a leading Sustainable Hub ○ providing a certification body for green-building products and services ○ international collaboration and global outreach ○ knowledge creation and mobilization on sustainable development	• Mitigation and adaptation strategies	• No lessons learned were identified
	Funder Networks • While no Funder Networks focused solely on advancing efforts to achieve net-zero health systems in Singapore were identified, sustainability funding is financed by local banks, such as UOB and DBS	• Mitigation and adaptation strategies ○ Investments using a net-zero approach or requirement	• No lessons learned were identified

Jurisdiction	Core features of identified strategic partnerships and/or funder networks	Types of strategies that are the focus of the partnership or network	Lessons learned from the partnership/network
	• The strategic focus of these banks is on sustainable financing in many sectors in society, including waste management, wind and solar energy, recycling, and water management, among many more • The DBS foundation is focused on societal progress through social entrepreneurship and achieving a path to net-zero		
	Funder Networks • While no Funder Networks focused solely on advancing efforts to achieve net-zero health systems in Singapore were identified, sustainability funding is provided by the Ministry of Sustainability and the Environment through its SG Eco Fund to support projects that advance environmental sustainability and involve the community • The SG Eco Fund is a $50 million fund launched in 2020 to support initiatives that advance environmental sustainability within the nation	• Mitigation and adaptation strategies ○ Investments using a net-zero approach or requirement	• No lessons learned were identified
Sweden	• No strategic partnerships identified • No funder networks identified		

U.K.	**Strategic Partnership**
	• The Centre for Sustainable Healthcare (CSH) in the U.K. works to engage health professionals, patients, and the community to reduce the resource footprint of the health systems; the Centre provides strategic input and consultancy on sustainable health systems research and practice
	• The priority areas of this strategic partnership include:
	  ○ Supply Chain and Patient Care Pathways Decarbonization
	  ○ Digital Innovation
	  ○ Consumer Health
	  ○ Wellbeing
		• Mitigation and adaptation strategies
		  ○ Energy-use reductions
		  ○ Decarbonizing the supply chain
			• Sustainable Markets Initiative recognizes the importance of agreeing upon a common set of metrics for evaluating change, and improved governance processes for a greater impact on sustainability from the private sector

	Strategic Partnership
	• The Green Nephrology initiative, established in 2009 within the National Health Service Sustainable Healthcare program, has systematically documented and implemented "green practices" across the whole U.K. dialysis spectrum
	• This program has changed both the appreciation of and attitudes toward resource conservation, reusability and waste management throughout the United Kingdom in a three-to-four-year time frame
		• Mitigation and adaptation strategies
		  ○ Energy-use reductions
		  ▪ Transportation and travel
		  ○ Non-energy emission solutions
		  ▪ Reuse and recycling
		  ○ Decarbonizing the supply chain
			• Green Nephrology has been proven to improve patient experience and sustainable efforts by reducing patient travel

	Funder Network • Triple Point Heat Networks Investment Management is committed to supporting net-zero emissions in health systems through its £320 million funding to heat network schemes across England and Wales	• Mitigation and adaptation strategies ○ Investments using a net-zero approach or requirement	• No lessons learned were identified
	Funder Network • National Health Service (NHS) England's Investment and Impact Fund is an incentive scheme targeted towards supporting primary care networks in becoming more sustainable	• Mitigation and adaptation strategies ○ Investments using a net-zero approach or requirement	• No lessons learned were identified
U.S.	**Strategic Partnership** • Health Care Without Harm – Massachusetts, in coordination with Boston Green Ribbon Commission (which is a cross-sectoral collaboration of 30 chief executive officers in	• Mitigation and adaptation strategies	• Health Care Without Harm – Massachusetts released a report on

Jurisdiction	Core features of identified strategic partnerships and/or funder networks	Types of strategies that are the focus of the partnership or network	Lessons learned from the partnership/network
	Boston), is focused on reducing energy use, greenhouse gas emissions, and advancing climate preparedness in healthcare facilities • This partnership is focused on reducing greenhouse gas emissions within health systems in the Greater Boston area, and has since led the first healthcare energy and greenhouse gas database to publicly report on trends and usage alongside collaborating with policymakers to push for energy efficient policies on the city and state levels		behalf of Boston's Green Ribbon Commission Health Care Working Group in July 2021, revealing that local healthcare facilities cut greenhouse gas emissions by 18% from 2011 through 2019, all while serving more patients and expanding facility spaces • In 2022, more than half of the hospitals in Massachusetts pledged to cut greenhouse gas emissions by 50% by 2030, and reach net-zero emissions by 2050; they are among 650 healthcare companies and organizations nationwide making the same commitment
	Strategic Partnership • Kimball Sustainable Healthcare is a leading organization that provides expert strategies, quality programs, and effective communication to help empower sustainable impacts in healthcare • The overall aim of this organization is to help health systems conserve resources and improve environmental performance by building the tools and partnerships to prevent waste and support quality, safety and value o Key areas of work have been centred around clinical recycling recovery, medical device disposal planning, and zero-waste compliance policies	• Mitigation and adaptation strategies o Non-energy emission solutions ▪ Reuse and recycling	• This organization's web page features a blog, which provides insight into how healthcare contributes to climate change and the mechanisms by which hospitals can become more climate resilient
	Strategic Partnership • Practice Greenhealth is a leading networking organization for delivering environmental solutions to health systems in the United States o This partnership includes hospitals, health systems, healthcare providers, design firms, and not-for-profit organizations, among others • This organization aims to develop a renewed health system that serves as an anchor for environment health and justice; it is built on an interconnected three-pronged strategy: o lead broader societal transformation o mitigate healthcare's impact o create community and healthy resilience	• Mitigation and adaptation strategies	• No lessons learned were identified

Appendix 9: References

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