Identifying Opportunities for Greenhouse Gas Reductions and Cost Savings in Hospitals: A Knowledge Translation Tree

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Abstract

Research has shown that the healthcare sector is among the least green sectors and constitutes one of the largest contributors to greenhouse gas (GHG) emissions, posing risks to human health. This review discusses the development of a knowledge translation tool that aims to compare a range of interventions that can be applied in hospital settings to reduce the local GHG emissions and associated financial costs. It discusses several interventions that potentially have the most impact on GHG reduction and compares these to interventions that are commonly used in different hospital departments. The authors propose opportunities to advance the implementation of these interventions within hospital operations across many other geographic locations.

Introduction

The World Health Organization (WHO) has identified climate change as an existential threat to human health and a major social determinant of health (WHO 2021). The WHO (2021) estimates that from 2030 onward, there will be an additional 250,000 deaths annually due to climate-driven diseases such as heat stroke, respiratory disease and vector-borne diseases. The effects of climate change in North America have a disproportionally negative impact on the health outcomes of non-white marginalized communities especially, including Indigenous, Black and low-income populations (Schnitter et al. 2022).

Operation of the healthcare system contributes to greenhouse gas (GHG) production through various causes such as waste production, energy use, direct emissions of inhaled anaesthetic gases and supply chain procurement of resources (Eckelman et al. 2018). The healthcare system alone produces 4.6% of annual GHG emissions in Canada, without accounting for anesthetic gas emissions (Eckelman et al. 2018). Of higher income nations, Canada has the fourth highest per capita GHG emissions from healthcare, globally (Vogel 2019). This is similar to other top polluting countries with high levels of emissions from healthcare, such as the UK, Australia and the US, accounting for 3–4%, 7% and 10% of national emissions, respectively (Vogel 2019).

Because the healthcare sector has been among the biggest contributors to GHG emissions, many previously called for making health risks due to climate change a key consideration in all climate-related policies and ascertaining whether each country's commitments represent an adequate contribution to GHG reductions under the *Paris Agreement* (Eckelman and Sherman 2016; Eckelman et al. 2018; Government of Canada 2016; Vogel 2019). However, the progress to meet the climate goals has not been nearly enough (Eckelman et al. 2018; Vogel 2019). This article aims to identify opportunities for local interventions for GHG emissions and cost savings in Ontario, Canada. By extrapolation, the authors propose to advance knowledge translation into an action to identify current opportunities for GHG reductions and cost savings within hospital operations across locations with a similar geography of carbon footprints.

Building a Safer, Low-Carbon Healthcare System

Various groups worldwide have been advocating for interventions that will decrease the environmental impact of the healthcare system. The authors of this study are from PEACH Health Ontario, a network of clinicians and administrators who are working together to make the healthcare system in Ontario more environmentally sustainable by promoting the implementation of actions to reduce GHG emissions (https://www.peachhealthontario.com/). In the process of promoting sustainability actions over the past year, it was found that few hospital administrators know how to move forward with "greening" their medical practice or healthcare facility.

There is a wide range of interventions for reducing GHG emissions within hospital operations, and they are not usually compared directly. While there are studies that focus on GHG savings of different sustainability projects, there remain several interventions that have little, if any, data. It also can be difficult to compare the efficacy and applicability of these projects when they often have vastly different outcome metrics. This review aims to standardize the environmental impacts of interventions through their impact on GHG emissions in order to compare interventions that are as different as apples and oranges. This review shows which interventions have the most impact on GHG reduction and which are the least costly to implement. It aims to create a user-friendly, visual knowledge translation tool that could be used by clinicians and administrators to compare the environmental impact of various hospital-based interventions and assess and/or prioritize which sustainability initiatives could be applied within their own healthcare setting.

This review shows which interventions have the most impact on GHG reduction and which are the least costly to implement.

Study Data and Methods

For this narrative review, the literature was searched for GHG emissions and carbon footprint mitigation in healthcare, and expert opinions were also included. We established an interdisciplinary working group inclusive of clinical, research and climate experts from the following backgrounds: anesthesiology, family medicine, engineering, knowledge translation, greening healthcare and data science. We held team meetings biweekly for five months to confirm project objectives, key categories and means to approach data collection and analysis. After discussions, we decided to focus on seven different categories of resource utilization in hospitals: leadership, education, buildings and energy, drugs and devices, supply chain, food and transportation. Our goal was not only to identify the most impactful interventions within hospitals but rather a range of examples for strategies.

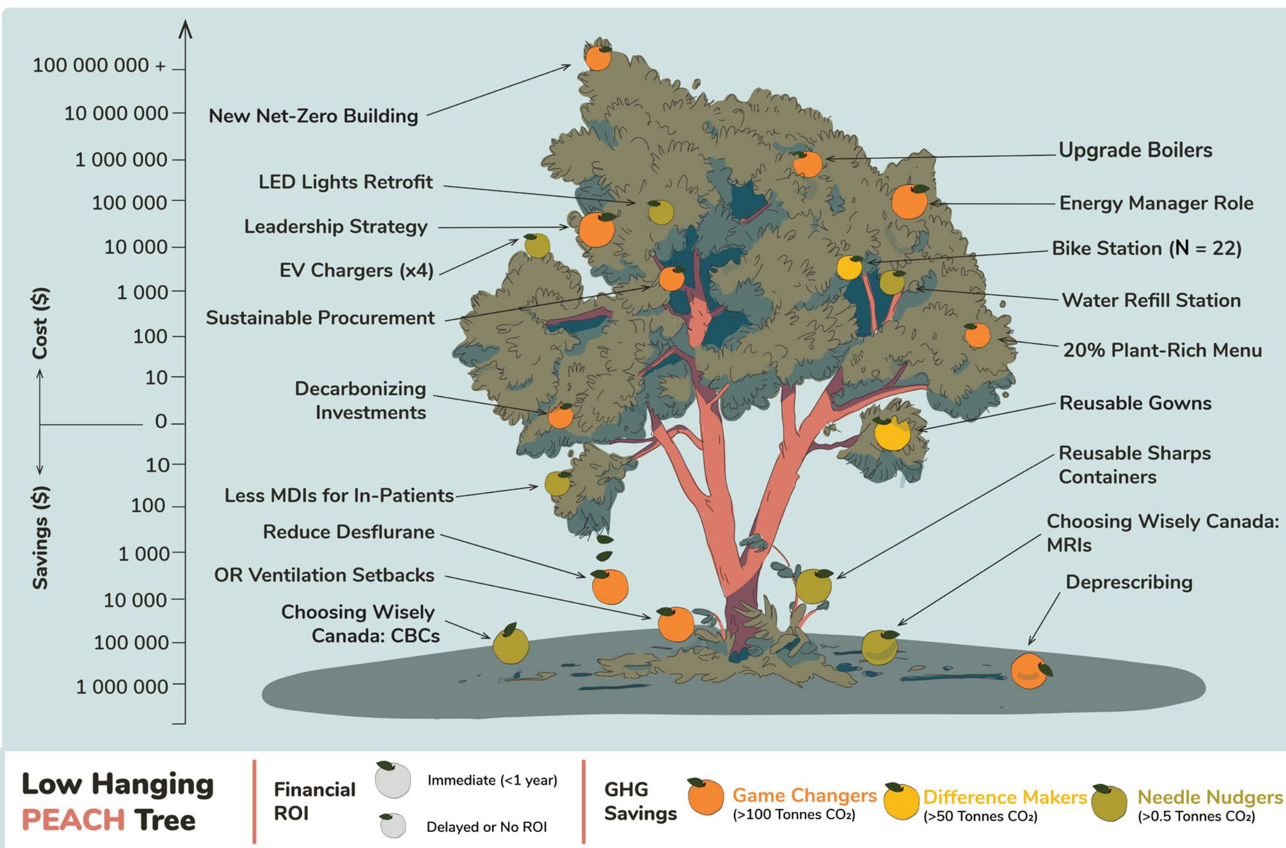
For each chosen hospital-based intervention, data were collected by performing a literature review from the period between 2010 and 2022 to identify the life cycle analysis (LCA) – which is a systematic analysis of the potential environmental impact of a product/process/service associated with all stages of their entire life cycles. Data were also collected from studies performed within the healthcare system to identify GHG changes and cost. There was a scarcity of data for several interventions, for which we subsequently gathered data from direct contacts within healthcare organizations in Ontario. We applied these findings to a standardized format of a 200-bed hospital (considered to be a medium sized urban hospital in Canada). Articles to support the numbers were extracted by searching the PubMed database, Google Scholar and websites of professional organizations. When no published or available data about an intervention were identified, we communicated with various hospital experts around the province of Ontario to elicit cost and GHG data. Because it was difficult to ascertain the exact reduction in GHG emissions (tonnes of CO_2) for each item, we assigned the interventions into three broad categories: small, medium and large GHG decrease. Each category had a range of GHG emissions: for example, the medium category constituted 50–99 tonnes/year. After all data points were defined and confirmed, the team collaborated with a professional artist and a knowledge translation expert to translate the quantitative data into a visual depiction of a "peach tree" (Figure 1) to help move knowledge into practice.

Summary of Main Findings

Table 1 summarizes which categories and interventions were found to have large, medium and small GHG reductions and cost savings (available online at longwoods.com/content/26946). Figure 1 illustrates a concise message using the analogy of a fruit tree, which shows the cost of a greening initiative on the vertical axis, indicating the financial return on investment (ROI) as the size of the fruit and the GHG reductions as the colour of the fruit as related to the ripening stage. This allows for the visualization of sustainability efforts at a glance. The results are based on the best information we could currently find and have shown that some of the usual initiatives, such as charging stations for electric vehicles (EVs) and reduction in paper usage, do not have nearly as much impact on GHGs as some other initiatives, such as deprescribing medications, decreasing the use of desflurane gas in the operating room (OR), decreasing the ventilation rates of ORs at night, hiring an energy manager and switching the patient menu to a plant-rich diet.

The "low-hanging fruit" analogy may offer positive opportunities for hospitals that want to quickly implement attainable and realistic activities in order to advance their greening goals. To reap the most benefits, it is important to understand which low-hanging fruit offers the most "game-changing" opportunities. Low-hanging fruits on the tree diagram are easier to implement because they are more economical. When saving money by implementing these items first, one could invest that money into starting to reach for fruits that are higher in the tree because of their cost.

FIGURE 1.
The peach tree diagram comparing the impact of interventions on costs and GHG emissions across seven different categories



CBC = complete blood count; EV = electric vehicle; GHG = greenhouse gas; LED = light-emitting diode; MDI = metered dose inhaler; MRI = magnetic resonance imaging; ROI = return on investment.
Image credit: Design concept by Myles Sergeant, illustration by Aidan Lucas and editing by Sujane Kandasamy and Eric Cook.

A Way Forward for Curbing the Carbon Footprint of Hospitals

Although this review aimed to develop a knowledge translation tool to compare interventions that can be taken at a hospital level to reduce GHG emissions and, ultimately, healthcare's impact on the climate, it encourages action. The "peach tree" visual (Figure 1) compares the estimates of cost and GHG reduction through the most impactful interventions across seven different categories: leadership, education, buildings and energy, drugs and devices, supply chain, food and transportation. While these data were primarily compiled with the purpose of application to Ontario-based healthcare facilities, the interventions enlisted in Table 1 may be generalized to healthcare facilities in other geographic areas, especially environmental locations that share similarities to Canada's energy infrastructure. Ultimately, climate change is a global crisis, and while countries may vary in approach, energy sources and healthcare systems, many of the same interventions may be applied globally to decrease healthcare's contribution to GHG emissions. Applying a similar approach to identify interventions applicable to other types of healthcare settings, such as long-term care homes, could be inferred.

Among all interventions, deprescribing is an important carbon reduction target and perhaps one of the simplest to execute. Evidence from the top-polluting countries is limited, but recent initiatives in the UK have suggested that overprescribing remains at unacceptable levels and that at least 10% of the total number of prescription medications in primary care are unnecessary (Department of Health and Social Care 2021). By inference, encouraging medication optimization, including deprescribing during hospital admissions, may reduce the overall number of prescribed medications and minimize environmental impacts and harms. In Canada, pharmaceuticals contribute to 25% of the healthcare-based GHG emissions (Eckelman et al. 2018). As such, our assumption is that an ambitious deprescribing campaign to reduce in-patient medication use by 5% in a 200-bed hospital setting would result in a reduction in carbon emissions by over 100 tonnes annually, while saving up to $1 million. We acknowledge that it will be difficult to set carbon targets for the reduction of overprescribing, mostly because of the current state of limited research. Our hope is to give a sense of the scale of the problem and the benefits that would emerge from implementing such a strategy.

We believe that a 5% reduction in the volume of prescription items is realistic. One specific example of the potential for medication optimization is antibiotic prescribing. At least 30% of the antibiotics prescribed in the outpatient, emergency department and long-term care settings in North America are deemed unnecessary (Brown et al. 2019; CDC 2016). While the overuse of antibiotics is not unique to Canada or the US, or to a single healthcare setting, such deprescribing programs can inspire changes in other healthcare settings and elsewhere in the world. We acknowledge that potential reductions are likely to vary in different settings and for different medications.

The supply chain, or the consumables within healthcare, is considered to account for the majority of GHGs in the system. It is difficult to carry out an accurate LCA of every individual item that we consume. The hospital and the procurement agencies currently do not award contracts for the items based on sustainability of the supplier. If environmental sustainability was added to the weighting of these contracts, we believe it will be a "game changer" within our industry. The potential for GHG reduction here is immense, and we can only speculate on the actual number. As a result, we have placed the supply chain in our large GHG reduction category.

Investors and institutions do not only want more climate disclosure data, they also want well-defined climate targets that are supported by achievable plans (Cleary and Hakes 2021; Frankel et al. 2015). For example, hospital foundations have investments, and a certain percentage would be in fossil fuel (FFs) funds. There would be significant GHG savings created by divesting from FFs. If healthcare systems want to mobilize the national and international capital necessary to compete in a low-carbon economy, they need to accelerate their pace to identify, fund and support companies that invest in their mutual efforts to decarbonize.

Medical imaging, including magnetic resonance imaging (MRI) scanners, is energy-intensive in its operation, estimated to emit 17.5 kg CO_2 equivalent per scan (McAlister et al. 2022). In Canada, the average number of scans done by a single MRI scanner is over 6,000 per year (CADTH 2021). Considerable energy- and cost-saving potential may be achieved if we order MRIs more prudently. Furthermore, MRI scanners in Ontario are mostly housed in hospitals, so even if a community physician orders an MRI testing, the procedure is done in a hospital setting, using hospital energy. Therefore, any reduction in ordering of MRI tests can have an impact on the hospital's carbon emissions. A Choosing Wisely Canada initiative has looked at the overuse of MRI scans (Choosing Wisely Canada 2017; McAlister et al. 2022). By examining our medical practice in hospitals and all the little bits and pieces of what we do every day, we can improve the stewardship of resources. Another example of what we believe could be improved in medical practice is the ordering of blood tests. In the in-patient setting, Choosing Wisely Canada recommends avoiding repeated complete blood counts (CBCs) and chemistry tests, in the face of clinical and laboratory result stability (Choosing Wisely Canada 2022). We believe that the savings accumulated by judicious use of resources could be applied to other aspects of care or hospital operations, such as providing preventive care or purchasing better technology. Alternatively, the resources "saved" could be redeployed within the hospital to allow for more patients to be taken care of without additional investment from the government and/or taxpayers.

"Leadership strategy" is an intervention that can create a cultural change and is a prerequisite for optimal outcomes. However, creating a culture of sustainability could take years for an organization to develop. Many of our proposed interventions are "top-down" strategies that can eliminate CO_2 equivalents very quickly, but the success versus failure of implementing all these strategies needs to be driven by a combination of "top-down" direction and "bottom-up" action.

The impact of the COVID-19 pandemic is another reason we have looked primarily at top-down items. The health system continues to combat the global health crisis, and hospitals are facing unprecedented human resource challenges. Many healthcare workers are currently ill, isolating, or taking a leave of absence or postponed vacations (Dyer 2022). Each COVID-19 wave has challenged healthcare systems, leading to increasing staff burnout rates, stress, trauma and ultimately, workforce shortages. This has not been an ideal time to ask healthcare workers to take on climate action.

The COVID-19 pandemic has also led to additional negative environmental consequences. This includes the burden of increased medical waste, haphazard use and disposal of disinfectants and disposal of personal protective equipment (PPE) composed of non-biodegradable plastics

(Mohamed et al. 2022). In addition to reusable gowns, some Canadian hospitals have introduced reusable respirators, which drastically reduce the need for single-use masks. There are other industry innovations on the horizon including plant-based masks and gloves. Our health system will need to continue to adopt new innovations in order to decrease the PPE waste burden.

Notably, there were several interventions that were not included based on their GHG impact but deserve to be mentioned, such as composting food, planting trees, implementing *all* the items in the Choosing Wisely Canada program (choosingwiselycanada.org) and having standardized surgical procedure or "surgeon's preference pick lists" in the operating room (OR). Future work would also need to focus on assessing the impact on resilience and how to enhance healthcare resilience for a changing climate, not just mitigation of environmental impact. While many people are doing admirable work to decrease healthcare's impact on climate, members of the healthcare community have a responsibility to collaborate, act now and address this climate crisis together. The novelty of this study lies in its focus on hospital settings, operationalization of practices to reduce carbon footprints and calls for creating performance dimensions for decarbonization.

Further research is needed for improved generalizability, empirical validation and deeper analysis of relationships between practice and performance in reducing the carbon footprint of healthcare. There has been a low quality of evidence on this topic, particularly due to heterogeneity, imprecision, small number of studies within each intervention class, risk of bias, publication bias and inconsistency between studies. There is also a paucity of LCA data in several healthcare categories, including pharmaceuticals and the supply chain, and there are few comprehensive studies identifying GHG savings from hospital-based interventions. While we tried to focus our review within Canada, several studies on LCAs that support our findings were based in regions with different power grid sources, such as the US. Furthermore, we converted data from studies with various outcome metrics such as kWh (kilowatt-hour) to GHG savings, which has a degree of error. We also converted the findings from hospitals of diverse sizes to a standard 200-bed hospital in a 1:1 bed adjustment. These simplifications limited the robustness of our calculations. Despite the limitations, we believe that the benefits would outweigh the downsides of our recommended interventions.

We did reduce the calculation errors in the fruit tree graphic by (1) using a logarithmic scale on the cost axis and (2) summarizing all the GHG numbers into three broad categories (small, medium and large). We believe that this work provides some concrete examples of ways to understand how healthcare systems can be proactive in undertaking meaningful decarbonization action at their respective locations.

Conclusion

While this work is still a novel area of exploration and analysis, these findings provide a positive model on how to tackle the carbon footprint and make a call for clinician action. It is hoped that both clinicians and administrators utilize this information to identify and implement interventions at their own hospitals. Although not much is known about the quality of carbon reduction initiatives in hospital settings, gaps were identified. The initiatives we have suggested will require further robust testing to ascertain whether these findings can be substantiated and generalized elsewhere. HQ

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