# Climate change and healthcare: Creating a sustainable and climate-resilient health delivery system

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## Summary

Climate change poses global challenges as rising temperatures, increased number and severity of disaster events, and the resulting increase in the prevalence of acute and long-term climate-related diseases threatens the health and safety of populations worldwide. The healthcare industry, one of the largest contributors to greenhouse gas emissions globally, both exacerbates and suffers from these impacts. As leaders in the community and the economy, hospitals and health systems have a responsibility to not only build the climate resilience to withstand disaster events, but also to implement sustainability initiatives that will lower the carbon footprint of the healthcare industry overall. A wide variety of initiatives that can meet all fiscal plans and timelines are available, however this discussion focuses on three of the most impactful areas for opportunity: building resilience through community, operating room sustainability, and renewable energy sources.

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The World Bank has predicted that by the year 2030, climate change will unwind all the gains made in global public health over the past 50 years, putting 100 million people into poverty and killing an additional 250,000 annually (Stancliffe & European Observatory on Health Systems and Policies, 2019). While these figures are daunting, the ability to act quickly and effectively is not out of reach. Furthermore, healthcare is uniquely positioned both within the economy and the community to impact positive and widespread change that can help to turn the tides of climate change.

At the individual level, hospitals and health systems can execute a two-pronged approach to climate change: preparedness and prevention. This plan requires leaders to develop pathways to establish climate-resilient healthcare delivery while simultaneously implementing strategies to reduce their carbon footprint. Contrary to common perception, making a concerted and effective effort towards sustainability is within the logistical and economic capabilities of nearly all healthcare systems. This essay demonstrates the current and future impacts of climate change on public health and healthcare delivery and costs, as well as implementable strategies for health systems to create climate-resilient and sustainable facilities.

## Healthcare Contributions to Climate Change

The healthcare industry is one of the largest contributors to carbon emissions in the United States, producing 8.5 percent of all greenhouse gas (GHG) emissions in the U.S. (Seervai, 2022a) and 7 percent of U.S. carbon dioxide emissions (Chung & Meltzer,

2009). This makes healthcare the second largest producer of emissions in the service sector behind agriculture, which lies at 11 percent of total GHG emissions *(Sources of Greenhouse Gas Emissions,* 2022*).* The United States healthcare sector also produces more emissions than any other nation's healthcare sector, accounting for about 25 percent of global emissions from healthcare activities (Eckelman, 2020). Most of these emissions come from the production and transportation of health sector services and goods, including pharmaceuticals, over which individual hospitals and health systems have limited control (Seervai, 2022a). However, almost 20 percent of total U.S. healthcare emissions are those that are produced directly from healthcare facilities (Seervai, 2022a). Collaboration across all areas of the sector, including the supply chain, individual hospitals, and health systems, is vital to driving GHG emissions down to achieve sustainability goals.

## The Impacts of Climate Change on Healthcare Delivery

As a geographically large nation, the U.S. experiences a broad range of natural disasters that continue to break new records and claim more homes and lives each passing year. In 2021 alone, the U.S. experienced 20 different weather and climate disasters, the second highest number on record behind 2020, which experienced 22 events (*Assessing U.S. Climate*, 2022). These events impacted all regions of the United States and varied widely in type of disaster, including one winter storm and cold wave event, one wildfire event that swept across seven different western states, one drought and heat wave event that spanned both summer and fall, two flood events, three tornado outbreaks, four tropical cyclones, and eight other severe weather events totaling $145 billion in damages

(NOAA National Centers for Environmental Information, 2022). The record for the most disaster-related deaths in the U.S. since 2011 was set in 2021 at 688 direct or indirect fatalities (*Assessing U.S. Climate*, 2022). Aside from natural disasters that cause catastrophic casualties, several studies, outlined below, have found that populations are also subjected to the less immediately obvious implications of climate change on health, including temperature-induced illnesses, increased respiratory illness, and supply chain shortages of necessary drugs and supplies, all of which contribute to both long-term and acute declines in overall health.

Rising temperatures are directly associated with an overall higher mortality rate, and although they disproportionately affect vulnerable populations such as the elderly and those with pre-existing diseases, they have the potential to affect healthy individuals as well (Seervai et al., 2022b). A study by Khatana et al., (2022) found that from 2008 to 2017, each additional "extreme heat day" (any day where the maximum heat index was greater than or equal to 90 degrees Fahrenheit) was associated with 0.07 additional deaths per 100,000 adults. The Lancet also reported that the number of heat-related deaths among people over 65–an at-risk population–doubled between 2000 and 2020 (Romanello et al., 2021). According to the National Oceanic and Atmospheric Association, it can be expected that heat waves above 100 degrees Fahrenheit will be more frequent, more severe, and longer-lasting (Kennedy, 2011). These high ambient temperatures have been found to be associated with increased utilization of emergency departments (ED); Sun et al. (2022) found an excess relative risk of ED visits for heat-

related illnesses, renal disease, and mental disorders in adult patients with health insurance.

As temperatures continue to rise, the power infrastructure strains to meet energy demands as more Americans utilize their air conditionings, leaving many areas vulnerable to power loss. Stone et al. (2021) found that over a five-year period between 2015 to 2020, the number of blackout events where 50,000 or more customers lost power for longer than one hour had increased by almost 60 percent, and their simulations estimated that 68 to 100 percent of the urban population was at risk of heat exhaustion or heat stroke during those periods. A preview of this occurred during the summer of 2022, when California experienced a record-breaking 10-day long heat wave which almost toppled its power grid (Von Kaenel, 2022). California Governor Gavin Newsom attributed the state's success in averting the disaster to their dedication to renewable energy via nuclear power plants, which allowed for an alternative solution to rolling blackouts that would have proved deadly for many residents in the heat. The ability of California and other states who do not have a robust renewable energy infrastructure to continue to withstand future heat waves poses a significant threat to under-resourced communities.

Health systems are also under threat of becoming victims of unexpected power outages. A 731-bed hospital in California suffered a power outage following the failure of their back-up generator during the previously referenced 2022 heatwave (Gamble, 2022). This power outage affected many of the campus's buildings, including the one that housed their emergency and trauma care, as well as two ICUs. In order to save their

patients' lives, the hospital had to coordinate transfers of all their ICU patients to another part of the hospital that had power within 30 minutes; the amount of time the back-up batteries on ventilators would last; stroke, trauma, and heart attack patients were diverted to another nearby hospital in the interim (Gamble, 2022). Hospital closures and loss of power during occupancy are possibilities with other types of climate events as well. During Hurricane Sandy in 2012, NYU Langone Medical Center in New York was forced to evacuate patients down a dark stairwell, and the result caused nearly $1 billion in damages, closed the main hospital for two months and the emergency department for a year and a half (Seltenrich, 2018). As global temperatures continue to rise and severe weather becomes worse, health institutions may expect to see similar emergencies occurring at higher frequencies.

In addition to rising temperatures, pollution and subsequent decreases in air quality and exposure to carcinogens in the air provide another area of concern for the health of communities. Wong et al., (2016) found a correlation between the concentrations of particulate matter (PM) in the air and an elevated risk of cancer in various organs; results of the study suggested that long-term exposure to this type of pollution can be associated with an increased incidence of lung, breast, liver, and pancreatic cancer. In addition to cancer, PM can cause and agitate respiratory diseases like Chronic Obstructive Pulmonary Disease (COPD), asthma, and bronchiolitis, as well as cardiovascular events, central nervous dysfunctions, and cutaneous diseases (Manisalidis et al., 2020). This type of pollution is becoming more concerning, especially in states on the West Coast, which are experiencing increasingly large

wildfires every year that drastically increase the number of particles in the atmosphere (Jaffe et al., 2020).

## The Impact of Climate Change on Healthcare Costs

Climate disasters and climate-related health issues pose a significant threat to the economic stability of healthcare systems individually, as well as the industry at large. The Healthcare Climate Council reports that a 30 percent reduction in the U.S. healthcare system's energy consumption by the year 2030 would prevent 4,130 premature deaths, 85,000 asthma attacks, 4 million respiratory symptom events, 3,750 hospital visits, and save $1.2 billion in medical costs (*Climate Action Playbook,* n.d.). The realities of this economic impact on healthcare are already emerging: Knowlton et al. (2011) examined six different categories of climate change-related events—ozone pollution, heat waves, hurricanes, infectious diseases outbreaks, river flooding, and wildfires—between 2000 and 2009 and determined that these events cost approximately $14 billion in health care costs and lives lost. Aside from costs associated with catastrophic events, an increase in the number of visits to the emergency department and hospitalizations due to both acute and long-term climate-related illnesses continue to drive up overall healthcare costs and place substantial economic burden on both healthcare organizations and patients (Wondmagegn et al., 2019).

One of the more devastating consequences of climate change which relates to both delivery and cost is the impact it has on the supply chain (Ghadge et al., 2020). Disaster events prevent ships carrying vital supplies from reaching their destinations, and as sea levels continue to rise and ports and coastal infrastructure begin to suffer, these

disruptions will increase in number (Leslie, 2022). Shortages come in many different forms–medical devices, drugs, even basic materials not immediately associated with medicine, like resin or microchips–making the supply chain's success and stability critically important to the lives of patients. This was illustrated during the COVID-19 pandemic when the unavailability of ventilators and other medically necessary devices cost patients their lives (Park et al., 2020). Similar instances of vital procurement issues have occurred in the United States during natural disasters such as Hurricane Idain 2021, which left a national shortage of IV bags (*IV Bag Shortage,* 2018). The U.S. Government has taken several steps to try and mitigate this issue for the future - most recently, President Joe Biden signed an Executive Order that will bring biotechnology manufacturing to the United States instead of shipping materials from overseas, which will provide more reliable supplies (Exec. Order No. 14081, 2022). The Food and Drug Administration similarly has taken steps to ensure stability and availability of medical devices (Federal Drug Administration, n.d.). However, it remains to be seen if these projects will be able to keep pace with the rate of climate events in the U.S.

## Strategies for Climate Resilience and Sustainability

While large-scale national and international efforts to combat the climate crisis remain an important and primary line of defense, it is becoming increasingly urgent for the healthcare industry to drive sustainability and mitigation efforts at all levels. Solutions to combat climate change as it pertains to hospital level interventions may fall within two categories: resilience and sustainability. Climate resilience refers to a hospital's ability to withstand the impacts of climate change, more specifically disaster

events. Sustainability in the context of business often involves efforts towards reducing or eliminating activities which negatively impact the environment and community (Spiliakos, 2018). There are many possible solutions, some of which address resilience and sustainability individually and others which address both. In order to be effective, solutions may be implemented within the context of strategic planning for the short-term as well as the long-term. In the short-term, it is necessary to develop and implement protocols to prepare for climate-related disasters such as power outages or hurricanes. In the long-term, it is important to also begin the work of implementing sustainable practices and green initiatives to reduce healthcare industry GHG emissions. How each healthcare institution or system approaches these efforts may differ based on their needs and capabilities, however there are many options for all types and sizes of facilities. The following examples are merely a few of the numerous options available.

**Building Community Resilience**

Community engagement and collaborations are low-cost and effective methods for building climate resilience. The Climate Resilience for Frontline Clinics Toolkit (*Climate Resilient Health Clinics,* n.d.) is a resource that was developed by The Center for Climate, Health, and the Global Environment at T.H. Chan School of Public Health in partnership with Americares to provide resources for free clinics and community health centers that help them prepare for climate crises. This toolkit was created using feedback from a survey of 450 clinic staff from 47 U.S. states and territories who had experienced climate crises in their home regions. The culmination of that survey supported the development of a diverse range of resources for patients, providers, and administrators. It

included information on conducting screenings and knowledge checks with patients to determine factors such as whether they have a functioning air conditioning unit in their home, or if they have an emergency preparedness plan, and provides the resources to help patients develop these solutions themselves. It also provides tailored resources for different types of climate disasters and extreme weather to help clinics and providers make swift and effective decisions in the event of an emergency.

The Climate Resilience for Frontline Clinics Toolkit allows clinics who may not have ample resources or finances at their disposal to effectively prepare their communities to mitigate the impact of climate disaster. It may also be integrated into existing social determinants of health programs run by health systems and organizations to help build climate resilience within the communities that they serve. Beginning resilience at the community level empowers patients to effectively manage their health and safety, making space for hospitals to serve other patients in need more effectively during disasters.

**Operating Room Sustainability**

Operating Rooms (ORs) generally account for around 40 percent of a hospital's expenses and around 60-70 percent of their revenue *(Greening the OR,* n.d.). Their operations and efficiency are incredibly important for the success of a facility; furthermore, their utilization is only increasing as more operations can be performed as ambulatory procedures (Koenig & Gu, 2013). However, ORs are also typically the most wasteful operation in the hospital, producing a third of the facility's waste and requiring 3-6 times more energy than the rest of the hospital (Rizan et al., 2020). Many facets of

OR operation that act in the interest of infection prevention such as air treatment systems and the use of disposable tools instead of reusable ones contribute a significant amount to the GHG emissions of the OR and create areas of opportunity for physical and energy waste reduction.

One of the largest contributors to the makeup of OR GHG emissions is anesthesia gases. In 2014, the use of desflurane and nitrous oxide, two volatile anesthetic gases used during surgery, released almost 3 million tons of carbon dioxide into the atmosphere (Gordon, 2020). These two gases have a higher affinity for trapping heat than methane, the most abundant contributor to GHGs. Anesthetic clinicians can make choices which can positively impact the carbon footprint of the OR by avoiding the use of desflurane and nitrous oxide where clinically appropriate and utilizing more sustainable alternatives such as sevoflurane (Yeoh et al., 2020). Other effective methods to reduce emissions due to gases include utilizing fresh low gas flows, which lowers the amount of excess gas dumped into the atmosphere, or intravenous anesthesia, which eliminates the use of gases altogether (Yeoh et al., 2020).

Waste segregation is another easy and effective way to reduce the GHG emissions of an OR. In hospitals overall but especially in ORs, waste is frequently erroneously put into the “hazardous waste” bins instead of regular waste bins (Wyssusek et al., 2019). There are two types of waste that are generally produced in the OR: regulated medical waste (RMW) and domestic waste. RMW is waste that has the potential to contaminate others, usually waste that would release blood or other infectious materials into the environment. These must be disposed of in a specific way as is regulated by the EPA,

usually through incineration. This process adds a significant amount of pollutant into the air and can create chemical run-off of controlled substances that harm the environment (Gautam et al., 2010). Domestic waste, on the other hand, is waste that can be disposed of normally without posing any significant threat. Despite the positive impacts of segregating waste correctly, a lack of education on the subject has been widely reported amongst OR clinicians. Agrawal et al. (2017) measured the rate of correct waste disposal in endoscopy units: 57 percent of the respondents reported that they regularly dispose of equipment that should be disposed as domestic waste as RMW, and 98 percent reported that they did not feel there was enough education on proper waste segregation. Initiatives to resolve this issue are high reward but relatively easy to implement; for instance, Hubbard et al. (2017) found that over the course of 51 surgeries performed, implementing the practice of only using domestic waste bins before the patient entered the OR effectively demonstrated a potential to reduce RMW waste by 13,800 kg per year per institution.

For a final strategy for reducing GHG emissions of the OR, look no further than the famous trifecta of sustainability: reduce, reuse, recycle. Polyethylene and especially polyethylene plastic, which is a blue sterile wrapping commonly used to store surgical equipment, can be replaced with hard cases to save an average of 5 tons of consumption a year at a facility (Lee & Mears, 2012). The selection of reusable surgical equipment during surgeries instead of single-use disposables can also have a significant impact. For ease of use and convenience to the surgeon, many hospitals will lay out a large variety of surgical tools, many of which never get used and must be disposed of afterwards. Using

reusable surgical equipment has been shown to reduce GHG emissions per case by almost 70 percent (Thiel et al., 2018). Overall, ORs create opportunities for areas of improvement, and provide a wide variety of options to tackle energy consumption and waste management problems for all organizations regardless of size. Implementing even just one of these strategies has great potential for not only curbing carbon, but costs as well.

**Electrical Grid Contingency**

Hospitals and healthcare facilities are some of the most energy inefficient buildings, using 2.5 times more energy per square foot than a regular office building (Demirkan, 2013). Most hospitals rely on regular gas and electricity for their energy sources, however investing in renewable energy can have a significant impact on the reduction of healthcare GHG emissions. There are many ways to accomplish this based on what a facility is capable of and the resources and available energy partnerships it has nearby. Rochester Regional Health in New York installed onsite solar panels as well as created an agreement with a nearby solar farm, the combination of which successfully powers 20 blood draw labs and 120 medical practices and support facilities (*Renewable Electricity Procurement,* n.d.). In 2017, Boston Medical Center completed construction on their own $15 million natural gas-fired combined heat and power (CHP) plant (*Boston Medical Center*, n.d.). This type of power plant has a “black start” capability, which would supply the hospital with heat and power for months at a time should the electrical grid go down. This is especially helpful in the event of a hurricane or severe storm that can leave areas without power for extended periods of time. Although they require a

significant amount of capital to invest to start with, CHPs create a more resilient hospital that can remain open and provide critical functions to patients and communities during disasters. More than 200 hospitals in 30 different states are utilizing CHPs as of 2022, and this change has proven to be a valuable resource for reducing costs, emissions, and in saving lives during severe weather *(CHP for Hospitals*, 2022). The government provides many incentives for installing CHPs as well; for instance, the Inflation Reduction Act provides a 30 percent Federal Tax Credit on CHP plants that begin construction before 2025 (Inflation Reduction Act of 2022, 2022), and Boston Medical Center received a $3.7 million grant from the Massachusetts Department of Energy Resources Community Clean Energy Resiliency Initiative in order to build their plant *(Boston Medical Center,* n.d.). Making the switch to a renewable energy source would potentially take several years, planning, and capital to implement, but it is a step that can be completed in phased projects, likely resulting in numerous benefits for the environment and community.

## The Economic Benefits of Sustainability Initiatives

"Go Green" initiatives are often stymied by the hefty price tag that is thought to accompany them (Lemonick, n.d.). The capital required to switch from existing fossil fuel infrastructure to renewable energy, or to purchase all new sustainable equipment and supplies, can be a significant barrier to entry for many facilities that already operate with slim profit margins. However, several studies, outlined below, have shown that implementing sustainable initiatives and investing in "green" equipment can be a good model for business, as well as good for the planet.

Most sustainability practices are founded on reducing resources wasted, whether that resource is water, energy, or disposable supplies. Reduction of that waste will inevitably lead to reductions in the amount of money spent on excess supplies. In 2012, the Commonwealth Fund projected that if all U.S. hospitals were to implement energy use reduction, waste reduction, and efficient purchase of operating room supplies the savings for the healthcare industry could exceed $5.4 billion over five years and $15 billion over 10 years (Kaplan et al., 2012).

Gunderson Lutheran, a hospital system in Wisconsin, found that by creating an energy efficient program, and through a variety of techniques including partnerships with local businesses, switching to a clean energy source like turbines, and upgrading equipment to energy efficient options they were able to offset energy costs for significant savings (Klein, n.d.). Gunderson Lutheran invested roughly $5 million into their initial energy audit, and by the end of the same year, saw $1.25 million in cost savings, offsetting energy use by almost 25 percent (Klein, n.d.).

Practice Greenhealth, a health care membership organization which provides resources on sustainability solutions to healthcare systems, has seen tremendous savings in the hospitals that have "greened" their operating rooms (*Greening the OR*, n.d.*)*. By implementing strategies such as HVAC setback, LED surgical lighting, medical device reprocessing, OR kit reformulation, reusable medical products, reusable sterilization containers, fluid management systems, and anesthetic gas reduction, hospitals have the potential to see a combined average of $20,060 in annual savings per operating room (*Greening the OR*, n.d.*)*. Although all these interventions require the capital to invest in

such projects, the potential return on investment is high enough to make it an appealing solution both for mitigating climate crisis and costs. Many hospitals who implement cost-saving sustainability initiatives recoup their money within five to ten years of the initial investment and are able to continue to reap the benefits of those cost savings for years to come (Kaplan et al., 2012).

There are also many low- or no-cost options available for implementation as well. Public data from a collection of 12 hospitals in Wisconsin recently demonstrated 9 percent in energy cost savings by utilizing low-cost operations and maintenance (Kaplan et al., 2012). They were able to reduce both GHG emissions and costs with low or no capital investment over a relatively short period of three to five years. This provides viable options for FQHCs or other hospitals with little to no capital to invest. In an age where both the temperatures and the costs of healthcare are on a steady incline, these interventions are simply good business.

## Conclusion

Although climate change poses a significant and continuously evolving threat, there is opportunity for the healthcare industry to impact significant and meaningful change that will help protect both the community and the industry. Over the next few decades, it will be crucial for hospitals and health systems to take the initiative both for their organizations and the communities that they serve to mitigate the effects of rising global temperatures. Combating climate change within the scope of healthcare will require enthusiastic and strong leadership from the executive level to the front line.

Given the feasibility and practicality of the sustainability and resilience interventions that have already been studied, coupled with the public health and economic benefits that these interventions can provide, all healthcare executives and healthcare facilities should commit to their implementation. Although these efforts may not turn the tide of climate change entirely, they will certainly help, and we must do all we can to be equipped for what the future must hold.

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