



Carbon Health Footprint of Healthcare Systems

Digital Health for Climate Resilience

Lecture 5

Lecture Outline

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The Healthcare Paradox

- **The Mission:** Healthcare systems exist to protect and improve human health
- **The Reality:** In fulfilling this mission, healthcare systems generate significant greenhouse gas emissions, contributing to climate change—the greatest health threat of the 21st century
- **The Paradox:** Places of healing are simultaneously sources of harm to planetary and population health
- **As the WHO Director-General has stated:** "Health sector facilities are the operational heart of service delivery, protecting health, treating patients, and saving lives. Yet health sector facilities are also a source of carbon emissions, contributing to climate change. Places of healing should be leading the way, not contributing to the burden of disease"



The Scale of the Problem: Healthcare's Global Climate Contribution

- **If the global healthcare sector were a country, it would be the 5th largest emitter on the planet**
- **Healthcare accounts for approximately 4.4% of global net greenhouse gas emissions**
- **This places healthcare ahead of entire countries like Brazil or Germany in terms of national emissions**
- **Regional Variation:**
 - High-income countries have a disproportionately large footprint.
 - The US healthcare system alone accounts for approximately 8.5% of US national emissions and 25% of the global healthcare footprint
 - Healthcare emissions in high-income countries are growing, driven by increasing demand, technological intensity, and population aging
- **The Trend:** Without intervention, healthcare's carbon footprint is projected to triple by 2050



Methodological Foundations: Carbon Accounting in Healthcare

- **Goal:** To quantify the greenhouse gas emissions associated with healthcare activities to identify hotspots, track progress, and inform decarbonization strategies
- **Key Methodological Approaches:**
 - **Carbon Footprinting:** Estimating the total GHG emissions directly and indirectly caused by an activity, organization, or product
 - **Life Cycle Assessment (LCA):** A comprehensive method for assessing the environmental impacts of a product or service across its entire life cycle—from raw material extraction, through manufacturing and use, to disposal ("cradle to grave")
 - **Input-Output Analysis:** Uses economic data to estimate emissions across supply chains
- **The Standard Framework:** The **Greenhouse Gas (GHG) Protocol** provides the most widely used accounting framework, categorizing emissions into three "scopes"



Understanding Scope 1, 2, and 3 Emissions in Healthcare

Scope 1 Direct Emissions

17%

Emissions from sources owned or controlled by the organisation

Examples:

- On-site fossil fuel combustion (heating & power generation)
- Anaesthetic gases
- Fleet vehicle emissions
- Refrigerant leaks

Scope 2 Indirect Energy Emissions

12%

Emissions from generation of purchased electricity, steam, heat & cooling

Examples:

- Electricity to power hospitals, clinics & equipment
- Purchased steam & heating
- Purchased cooling systems

Scope 3 Supply Chain Emissions

71%

All other indirect emissions in the organisation's value chain

Examples:

- Pharmaceuticals, medical devices & food (production + transport)
- Waste disposal
- Business travel
- Employee commuting

Share of healthcare emissions →

Scope 1 · 17%

Scope 2 · 12%

Scope 3 · 71% (vast majority)

Hotspot 1: Hospital Operations and Energy Use

- **Hospitals are energy-intensive facilities**, operating 24/7/365 with demanding requirements for heating, cooling, ventilation, and lighting
- **Key Contributors:**
 - **HVAC Systems:** Heating, ventilation, and air conditioning account for a large share of hospital energy use
 - **Medical Equipment:** Energy-intensive devices like MRI machines, CT scanners, and ventilators
 - **Lighting and IT Infrastructure:** 24-hour operations require continuous lighting and data center power
- **A 2025 study of a Shanghai hospital found:**
 - The **operation stage accounted for 73.1% of the hospital's total life cycle carbon footprint**
 - Within operations, **medical equipment systems contributed 43.3% of emissions**, while conventional energy systems (HVAC, lighting) contributed over 50%
- **Opportunity:** Energy efficiency upgrades, on-site renewable energy, and smart building management systems can significantly reduce Scope 1 and 2 emissions

The Supply Chain (Pharmaceuticals and Medical Devices)

- **Scope 3 emissions dominate the healthcare footprint**, and within Scope 3, pharmaceuticals and medical devices are the largest contributors
- **Pharmaceuticals:**
 - Manufacturing processes are energy- and resource-intensive
 - Complex global supply chains with multiple stages and long-distance transport
 - Active pharmaceutical ingredients (APIs) often manufactured in facilities with high carbon intensity
- **Medical Devices:**
 - Single-use devices (syringes, gloves, drapes) generate significant embodied carbon and waste
 - Manufacturing of high-tech equipment (imaging, implants) is energy-intensive
- **Systematic Review Findings (ScienceDirect):**
 - Only **29% of drug studies** considered a full "cradle-to-grave" life cycle perimeter
 - Only **11% included end-of-life waste treatment**
 - Industrial secrecy limits access to emission factors, hindering accurate accounting



The "Minimally Invasive ≠ Low-Carbon" Paradox

- **Common Assumption:** Minimally invasive surgery is clinically superior and intuitively seems like it should have a lower environmental impact
- **A 2025 Study in *Scientific Reports* on minimally invasive axillary osmidrosis surgery challenged this assumption**
- **Findings:**
 - The procedure generated **50.48 kgCO₂e per surgery**
 - **Facility operations** (HVAC, lighting) were the largest contributor at **43.5%**
 - **Disposable consumables** (sterile drapes, gloves) contributed **21.7%** , with sterile drapes and gloves alone accounting for 78.8% of consumable emissions
- **Key Insight:** Clinical minimalism does not guarantee environmental minimalism. The reliance on single-use, sterile disposable products in modern surgery has a significant carbon cost

Hotspot 3: Anaesthetic Gases and Inhalers

- **A Unique Opportunity:** These clinical products represent a relatively small percentage of total emissions but offer a high-impact, low-effort decarbonization opportunity because clinically equivalent lower-emission alternatives exist
- **Anaesthetic Gases:**
 - Potent greenhouse gases, many with global warming potentials hundreds to thousands of times greater than CO₂
 - **Desflurane** has a global warming potential ~20-25 times that of sevoflurane
 - Released directly into the atmosphere during surgery (Scope 1)
 - Account for approximately **0.6% of healthcare's global climate footprint**
- **Metered-Dose Inhalers (MDIs):**
 - Use hydrofluorocarbon (HFC) propellants, which are potent greenhouse gases
 - Account for approximately **0.3% of healthcare's global climate footprint**
 - **Dry powder inhalers (DPIs)** have a significantly lower carbon footprint and are clinically appropriate for many patients
- **Combined Impact:** ~1% of global healthcare emissions, with readily available alternatives

Hotspot 4: Food and Agriculture in Healthcare

- **Hospital Food Systems:**
 - Hospitals serve millions of meals daily, making food procurement a significant source of Scope 3 emissions
 - Meat and dairy, particularly red meat, have high carbon footprints
 - Food waste is a major contributor; wasted food means wasted embodied carbon
- **Opportunities:**
 - **Sustainable Procurement:** Prioritizing plant-based and sustainably sourced food
 - **Reducing Food Waste:** Better menu planning, portion control, and composting
 - **Health Co-Benefits:** Plant-based diets aligned with chronic disease prevention
- **Example:** The **Cleveland Clinic** and other US health systems have implemented "plant-forward" menu initiatives, reducing meat consumption and associated emissions while promoting heart health



Hotspot 5: Travel and Transport

- **Sources:**
 - **Patient Travel:** Patients and families traveling to and from healthcare facilities
 - **Staff Commuting:** Healthcare workers commuting to work
 - **Fleet Vehicles:** Ambulances and other service vehicles
 - **Business Travel:** Staff travel for conferences, training, etc.
- **Contribution:** A significant but often under-measured component of Scope 3 emissions
- **Opportunities:**
 - **Telemedicine:** Reducing patient and staff travel by providing remote consultations
 - **Active and Sustainable Commuting:** Encouraging cycling, walking, public transport, and carpooling among staff
 - **Electric Vehicle Fleets:** Transitioning ambulances and other fleet vehicles to electric
 - **Remote Conferencing:** Reducing business travel through virtual meetings

The OECD Analysis: Hospital Contributions and Decarbonization Potential

- **A 2025 OECD report on decarbonising health systems** provided critical quantitative analysis
- **Key Findings:**
 - **Hospitals represent approximately 30% of healthcare emissions** on average across OECD countries
 - This is because hospitals are highly resource-intensive settings
 - **Reducing inappropriate care and hospital stay duration** could cut hospital-related emissions by **up to 25%** on average across OECD countries
- **The Logic:** Low-value care (tests, procedures, admissions that provide no clinical benefit) generates emissions without improving health. Reducing it is a "win-win"—better health outcomes, lower costs, and lower emissions
- **Example:** Reducing unnecessary elective surgeries, avoiding inappropriate admissions, and shortening lengths of stay where clinically appropriate

From Measurement to Action: Decarbonization Strategies

- **Measure and Benchmark:** Conduct comprehensive carbon footprinting to identify hotspots and establish a baseline
- **Set Targets:** Adopt science-based targets aligned with the Paris Agreement (e.g., net-zero by 2050, with interim goals)
- **Decarbonize Operations (Scopes 1 & 2):**
 - Energy efficiency (LED lighting, smart HVAC, efficient equipment)
 - On-site renewable energy (solar panels)
 - Procure renewable energy
 - Transition to low-carbon anaesthetic gases
 - Electrify fleet vehicles
- **Transform the Supply Chain (Scope 3):**
 - **Sustainable Procurement:** Integrate carbon criteria into purchasing decisions
 - **Supplier Engagement:** Work with suppliers to reduce their emissions and improve transparency
 - **Reduce, Reuse, Recycle:** Shift from single-use to reusable devices where clinically appropriate; reduce waste
 - **Low-Carbon Formularies:** Prioritize pharmaceuticals and inhalers with lower carbon footprints
- **Redesign Care Pathways:**
 - Reduce low-value care
 - Expand telemedicine
 - Promote plant-based menus
 - Encourage active transport for staff and patients

Case Study: ULT Freezers in Catalonia

- **The Problem:** Ultra-Low Temperature (ULT) freezers, used to store biological samples and medicines at -80°C , are extremely energy-intensive
- **The Intervention:** The **IDIBELL** research institute in **Catalonia** implemented a simple policy change: **increase the temperature set point from -80°C to -70°C**
- **The Evidence:** Research has shown that the vast majority of biological samples are stable at -70°C ; the additional cooling to -80°C consumes significant extra energy for minimal gain
- **The Impact:**
 - Upgrading just **10 freezers** cut **4.2 tons of CO_2 annually** —equivalent to the emissions of nearly 5 households
 - Significant cost savings on electricity bills
 - No compromise on sample integrity
- **Key Lesson:** Simple, low-cost, behaviorally focused interventions can yield significant emissions reductions

Case Study: The NHS Net Zero Commitment

- **Context:** The UK's National Health Service (NHS) is the first national health system to commit to net-zero emissions
- **The Commitment (2020):**
 - **For emissions it directly controls (Scopes 1 & 2):** Net-zero by 2040
 - **For emissions it can influence (Scope 3, supply chain):** Net-zero by 2045
- **Key Strategies:**
 - **Greener NHS Programme:** Dedicated team to drive decarbonization
 - **Sustainable Procurement:** Embedding carbon reduction in all contracts
 - **Low-Carbon Clinical Care:** Reducing anaesthetic gas emissions, switching inhalers
 - **Travel and Transport:** Transitioning fleet to electric vehicles, promoting active travel
 - **Energy Efficiency:** Retrofitting hospitals, installing solar panels
 - **Food:** Plant-based menus, reducing food waste
- **Impact:** The NHS is demonstrating that large-scale, systemic decarbonization of a complex health system is possible, providing a model for others

The Ethical Imperative: First, Do No Harm

- **The foundational principle of healthcare is "First, do no harm"** (Primum non nocere)
- **Climate change is a health crisis.** By contributing to it, healthcare systems are violating this core principle
- **Therefore, decarbonizing healthcare is not an optional extra or a niche environmental concern—it is a core ethical and professional responsibility**
- **Health professionals have a unique voice and credibility** to advocate for climate action both within their institutions and in society at large
- **Key Questions for Reflection:**
 - Can we claim to be healing patients while our operations are making the planet sicker?
 - What is our professional obligation to address the root causes of climate change?
 - How do we balance the immediate needs of an individual patient with the long-term health of the population?

Challenges and Opportunities

- **Challenges:**

- **Data Gaps:** Lack of granular, reliable data on emissions, especially Scope 3 and in LMICs
- **Financial Constraints:** Upfront costs of efficiency upgrades and renewable energy
- **Complexity of Supply Chains:** Healthcare supply chains are global and deeply entrenched
- **Clinical Culture:** Ingrained practices (e.g., preference for single-use, certain anaesthetics) can be resistant to change
- **Conflicting Priorities:** Climate action can be seen as competing with immediate clinical and financial pressures
- **Regulatory Gaps:** Lack of mandates or incentives for decarbonization in many jurisdictions

- **Opportunities:**

- **Cost Savings:** Energy efficiency and waste reduction often save money in the long run
- **Health Co-Benefits:** Many decarbonization actions (plant-based diets, active transport, reduced air pollution) directly improve health
- **Innovation:** The drive to decarbonize is spurring innovation in green technologies, products, and care models
- **Leadership:** Healthcare can lead by example, demonstrating that climate action is possible and beneficial
- **Workforce Engagement:** Health professionals are increasingly demanding action and can be powerful agents of change

Conclusion and Key Takeaways

- **Healthcare is a significant contributor to climate change**, accounting for approximately 4.4% of global emissions—comparable to the fifth-largest country
- **The majority of emissions (71%) come from Scope 3 supply chains**, particularly pharmaceuticals and medical devices, not just hospital energy use
- **Key hotspots include** hospital operations, anaesthetic gases, inhalers, food systems, and travel
- **Clinically equivalent, lower-emission alternatives exist** for many practices (anaesthetic gases, inhalers, single-use devices)
- **Reducing low-value care offers a "win-win"** —better health outcomes, lower costs, and lower emissions
- **Decarbonization is an ethical imperative**, grounded in the core principle of "First, do no harm"
- **Action is possible and underway**, as demonstrated by the NHS net-zero commitment, hospital-level initiatives, and simple interventions like ULT freezer temperature adjustments
- **Health professionals have a critical role to play**—as advocates, as change agents within their institutions, and as role models for sustainable practices

Q&A / Discussion

Thank you.

Questions?

- How can we accelerate the transition to low-carbon, sustainable healthcare in low-resource settings?
- What is the role of professional education in preparing a climate-literate health workforce?
- How do we balance the imperative to reduce emissions with the need to expand access to healthcare in underserved populations?
- What single change would you advocate for in your own healthcare context?

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