INTRODUCTION

In October 2018, the Intergovernmental Panel on Climate Change (IPCC) issued an alarming report which found that staving off the worst impacts of climate change by limiting global warming to 1.5°C, the ambition of the Paris Agreement, would "require rapid, far-reaching and unprecedented changes in all aspects of society."

Such thoroughgoing change, according to the IPCC, would need to include transitions in land, energy, industry, buildings, transport, and cities, that reduced global net human-caused emissions of carbon dioxide (CO_2) "by about 45% from 2010 levels by 2030, reaching 'net zero' around 2050".[1]

"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. The world's health sector facilities churn out CO_2 through the use of significant resources and energy-hungry equipment. This is perhaps ironic — as medical professionals our commitment is to 'first, do no harm.' Places of healing should be leading the way, not contributing to the burden of disease."

- Tedros Adhanom Ghebreyesus,
Director General, World Health Organization

This stark and urgent message from the world's leading climate scientists, together with a relentless, ongoing assault of extreme weather and other climate impacts around the world today, presents a clarion call for a rapid transformation of the global economy to a low-carbon, and ultimately zero-emissions future. It has spurred a growing number of institutions and jurisdictions to declare a "climate emergency." For instance, at the time of publication, nearly 900 local governments in 18 countries had declared climate emergency and committed to action to rapidly reduce emissions.[2]

This paper focuses on how the health sector, which sits on the front lines as a first responder to climate change, also makes a heretofore little recognized but significant contribution to the problem. The paper argues that health care must respond to the climate emergency not only by treating those made ill, injured, and dying from the climate crisis and its causes, but also by practicing primary prevention by radically reducing its own emissions.

Despite its clear identity as a cohesive sector of society with a robust private dimension and governance bodies at local, national and global levels — a sector that collectively spend $7.2 trillion annually or 10% of world GDP[3] — health care's emissions footprint has been largely ignored by those addressing climate change over the past quarter century. The health sector itself has paid scant attention until recently.

This paper takes the most comprehensive[a] look at health care's climate emissions to date in order to build an understanding of where the problem comes from so that this challenge can be tackled not only without compromising the quality of care, but by potentially improving it. The paper identifies a path forward that can empower health systems, ministries, multilateral and bilateral health lenders and donors, together with suppliers and manufacturers of health goods and services, to begin to take cost-effective, urgent action to move toward net zero emissions in order to protect public health from climate disruption.

a. Global spending data together with detailed information on 43 countries provides global coverage that allows for a comparison among nations and many regions of the world.

Climate change is a health issue

Climate change is damaging human health today and will have a greater impact in the future. *The Lancet* has called it the "biggest global health threat of the 21st century."[4]

Direct climate impacts, such as the spread of vector-borne disease, increased heat, drought, severe storms, and flooding as well as the mass migration of climate refugees, have health consequences that will disproportionately affect the most vulnerable and marginalized populations and increase in intensity over time (Figure 1).

All countries will experience significant and growing health impacts from climate change. Low- and middle-income countries will see the worst effects as they are most vulnerable to climate shifts and least able to adapt given weak health systems and poor infrastructure. Climate change could drag more than 100 million people back into extreme poverty by 2030 with much of this reversal attributable to negative impacts on health.[5]

The "lack of progress to date in reducing emissions and building adaptive capacity threatens" not only "human lives and the viability of the national health systems they depend on," according to the Lancet Countdown on Health and Climate, but also has "the potential to disrupt core public health infrastructure and overwhelm health services."[6]

Hospitals, health centers, and public health workers are first responders to the health effects of climate change. Hospitals and health systems will inevitably bear high costs resulting from the growing number of extreme climate events and must become resilient to climate's impacts. Some of the poorest health systems in the world are often some of the most vulnerable both in harm's way and without tools and resources to protect themselves.

At the same time, the main driver of climate change — fossil fuel combustion — is causing major health problems now, contributing to air pollution that prematurely kills more than seven million people a year, roughly twice as many people as HIV AIDS, Malaria, and TB combined.[7] Air pollution also makes a major contribution to long-term chronic diseases that require treatment and hospitalization, which in turn contributes to increased health sector spending and emissions. This is linked with inequity as more than 80% of premature deaths attributed to non-communicable diseases occur in low- and middle-income countries. The worst effects and causes of climate change can be prevented, and such prevention presents a significant opportunity to simultaneously improve health outcomes and increase health equity.[8]

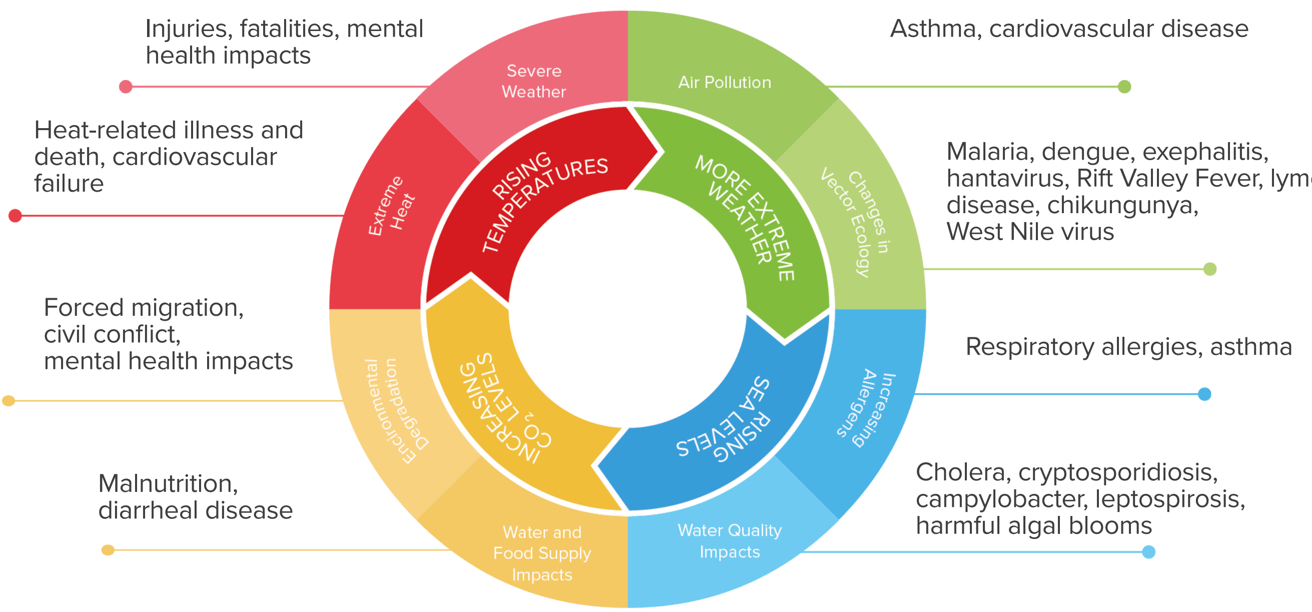

Figure 1: Impact of climate change on human health (Source: U.S. Centers for Disease Control and Prevention)

Health care's climate impact

While vastly differing in scale, each nation's health sector directly and indirectly releases greenhouse gases (GHG) while delivering care and procuring products, services, and technologies from a carbon-intensive supply chain. Health care contributes to carbon emissions through energy consumption, transport, and product manufacture, use, and disposal.

Indeed, the health sector, which comprises 10% of world GDP and is dedicated to preventing, treating, and healing disease, cuts across many of the categories often associated with climate footprint measurement. Yet until recently it has not been measured as a coherent segment of the world's climate footprint.

In recent years, comprehensive health care climate footprint measurements were undertaken in a few countries. Two studies in the United States found the country's health care emissions to alternately have reached 8%[9] and 9.8% of the national total respectively, with the latter estimate comprising 655 million metric tons of carbon dioxide equivalent (CO_2e).[10] In the United Kingdom, the National Health Service (NHS) and Public Health England estimated the health and social care climate footprint in England in 2017 to be 27.1 Mt CO_2e, representing around 6.3% of the country's climate footprint.[11] Similar studies had comparable findings in Australia (7%)[12] and Canada (5%).[13]

Until recently, no one had undertaken a comprehensive global study of health care's emissions. In 2017, the World Bank, in collaboration with Health Care Without Harm, published an estimated calculation which found that the health care sector generated 2.6 billion out of the 52 billion metric tons of CO_2e globally emitted in 2011 — or 5% of global emissions.[14]

In 2018, the Kigali Cooling Efficiency Program (K-CEP) published a study on global emissions from cooling in health care. It found that globally, roughly 365 Mt CO_2e (+/- 90 Mt) annually comes from energy used to provide hospital cooling. This is equivalent to the emissions from over 75 million cars on the road or 110 coal power plants for an entire year. The study did not take into account harmful F-gases (HFCs, HCFCs) used in cooling, which would make the number even higher.

The study found that reducing the energy used for hospital cooling and refrigeration by 30% could abate ~110 Mt CO_2e per year currently, equivalent to installing 27,400 wind turbines.[15]

In 2019, an in-depth study by Pichler et. al. published in Environmental Research Letters examined all Organization for Economic Cooperation and Development (OECD) countries (minus Chile), plus India and China. It found that the health care sectors of the 36 countries sampled combined were responsible for 1.6 $GtCO_2$e emissions or 4.4% of the total emissions from these nations in 2014. Their study provides the first comparable estimates of CO_2 emissions of health care across a large group of nations that comprise 54% of the world's population and 78% of world GDP.[16]

This paper's contribution

Until recently, both the health sector and the climate community have had limited awareness of the significant contribution the sector makes to greenhouse gas emissions, and with it the need to take thoroughgoing action to align health care with the ambition of the Paris Agreement. This report, together with other emerging research, provides baseline information that can inform a pathway to health care decarbonization via sector-wide action. The areas of the report's groundbreaking findings include the following:

Global estimate: This report establishes the first-ever detailed estimate of health care's global climate footprint. It makes several contributions to the world's understanding of the extent of health sector emissions and their sources. In doing so it builds on the growing base of knowledge of health care's climate footprint.

This paper also goes further than previous work in terms of number of countries covered in detail and number of greenhouse gases considered. The World Input-Output Database (WIOD) database was employed and covers all remaining countries in the world, albeit with much less detail. This has allowed us to produce a global estimate with reasonable confidence (Section 2 - Study methodology).

The study breaks down the estimate in several ways, including looking at both absolute and per capita health sector emissions by country and region, as well as correlations between health care spending and sector emissions by country.

Regional estimates: The study has developed an approach that allows us to reasonably disaggregate health care's climate footprint for world regions where sufficient data exists. Thus, it provides regional estimates for East Asia and the Pacific (and within that, ASEAN countries), Europe and Central Asia (and within that, the European Union), Latin America and the Caribbean, and South Asia.

A particular focus in this paper is given to the European Union as a political union that is forging a collective political response to the climate crisis. It has set block-wide goals which drive action on a national level, and therefore this study considers the EU as an entity when making comparisons with major emitters such as the United States, China, and other nations. (Specific data for all 28 EU countries is available in Appendix A)

Given lower data quality for the countries of Africa and the Middle East collected by our chosen database, we elected not to report regional results for these important parts of the world; subsequent updates to this methodology and footprint will seek to address this gap.

Alignment with the Greenhouse Gas Protocol: The report breaks down global emissions according to the framework established by the Greenhouse Gas Protocol, the world's most widely used greenhouse gas accounting standards. It aligns World Health Organization (WHO) health sector definitions with an emissions analysis organized by the categories of Scope 1 (direct emissions from health care facilities), Scope 2 (indirect emissions from purchased energy), and Scope 3 (all indirect emissions, not included in scope 2, that occur in the value chain, including both upstream and downstream emissions).

This aligns the health care sector estimate with the same framework being used by many other sectors, sub-national and national governments, and health care systems and facilities. It is important to note that the proportions attributed to the three scopes in the global and country estimates will differ from, for instance, a hospital's estimate of its scopes, in that this study covers the entire health sector and therefore includes, for instance, health care insurance providers or retail outlets for medical devices. (See Appendix B for further details.)

Country estimates broken down by scope: The study provides five sample country estimates based on GHG Protocol scopes. Similar analyses for all 43 countries are available online in supplemental material. It is important to note that the health care climate footprint estimates in this report may differ from the handful of national studies that have been carried out. National studies have access to more precise and granular data at a country level, which can facilitate a more specific level of reporting, while this study is using a global database to produce a global estimate, as well as a series of national estimates based on that data.

Analysis by economic sector: The study has traced health care's climate footprint back to the original emissions sectors covered in the WIOD database. This has allowed for a wide-angle snapshot of most sources of the health care sector's emissions, including energy, transportation, agriculture, pharmaceutical production, and more.

Anesthetic gases and metered-dose inhalers: While limited by the use of data from only 31 countries, the study generates a conservative estimate of the climate impact of anesthetic gases — highly potent greenhouse gases — and metered-dose inhalers, which use them. Due to different data sources, these estimates are not included in the overall global estimate of health care's footprint, but are in addition to it.

Research agenda: The study identifies a number of areas where further research and methodological development can help support the sector in its efforts to understand and address its climate footprint.

Policy recommendations: Based on the findings, the study sets forth a group of recommendations based on our growing knowledge of the important role that health care plays in relation to climate change, along with the imperative of the sector to align with the Paris Agreement and meet its sustainable development goals.

Health care taking climate action

Several health care institutions in multiple countries are already leading the way toward decarbonization. These hospitals and health systems in both developed and developing countries are serving as models by implementing a set of actions to reduce their climate footprint and/or become carbon neutral, while also building resiliency and taking leadership action. The following are some examples. There are many more.

The Health Care Climate Challenge:[54]
Launched in 2015 at the Paris Climate Conference, the Health Care Climate Challenge is a Health Care Without Harm initiative to mobilize health care institutions around the world to play a leadership role in addressing climate change.

The Challenge and its pledge, which institutions sign to participate, are based on the three pillars of mitigation, resilience, and leadership.

To date, more than 190 institutions representing the interests of over 18,000 hospitals and health centers from 31 countries, have joined the Challenge and committed to taking action. Participants range from small health centers to large health systems. So far, together they have committed to reducing emissions by 30 million metric tons.

100% renewable electricity: In 2018, as part of the Challenge, Health Care Without Harm began collecting commitments from health care facilities around the world to target using 100% renewable electricity. To date, 21 institutions in 12 countries have signed on and in doing so are raising the bar for sustainable health care on every continent.

In making this commitment, health care is joining thousands of cities,[55] companies,[56] higher education,[57] and other organizations making similar commitments as part of a worldwide effort to accelerate the transition from dependence on fossil fuels to an economy based on clean, renewable energy such as wind and solar.

When fully implemented, these 21 institutions will collectively be serving over 23 million patients per year at health care facilities powered by 3.3 billion kilowatt hours of renewable electricity. In doing so, they will have reduced their aggregate annual GHG emissions by over 1 million metric tons of CO_2e.

Health care climate action by region

Europe: England's NHS reduced the health and social care climate footprint — including Scopes 1, 2, and 3 – by 18.5% since 2007. Its goal is to comply with the country's Climate Change Act, which sets a requirement of reducing the footprint further so that United Kingdom achieves a 34% reduction by 2020 and an 80% reduction by 2050.[58] There are other outstanding local and regional examples in Europe, particularly in Scandinavia and the Netherlands, where zero emissions hospital buildings, increasing organizational commitments to carbon neutrality, innovative climate-smart technologies, and strategies to address supply chain emissions are being adopted in the sector.[59]

North America: In the United States, where, arguably the most work needs to be done, several major health systems are moving toward decarbonization in Scopes 1 and 2. For example, Kaiser Permanente, one of the largest U.S. non-profit health systems, is committed to being carbon net positive by 2025; the University of California Health System has set a goal of 2025 for carbon neutrality; and Cleveland Clinic aims to be carbon neutral by 2027.[60] Several Canadian health systems are also committed to carbon neutrality.

Latin America: In Latin America more than 175 hospitals in Argentina, Brazil, Chile, Colombia, and Costa Rica, working in collaboration with Health Care Without Harm's Global Green and Healthy Hospitals Network, have calculated their climate footprints and are making reduction commitments.

Africa: In Africa, the Mohammed VI University Hospital has set the target of 100% renewable electricity by 2030. They will achieve this through investments in on-site solar and geothermal energy. In Zimbabwe, UNDP's Solar for Health Program has installed solar arrays to power more than 400 health centers, facilitating quality care, cutting costs and building resiliency with zero emissions. In South Africa, Netcare, a private health system, has a target to reduce their emissions by over 35% by the year 2023. Solar energy is a key component of this effort. They currently have solar panels providing 10MW of power with plans for further expansion.

Asia: In South Korea, Yonsei University Severence Hospital has committed to a 30% reduction of carbon emissions by 2020, equal to nearly 12,000 metric tons of CO_2e. In India, the Chhattisgarh State Renewable Energy Development Agency (CREDA) and State Health Department have collaborated to install, operate and maintain solar PV systems in 900 health centres and district hospitals, reducing their carbon footprint while building resiliency. Many other Indian large hospitals and small health centers are also pursuing climate-smart strategies. Similar initiatives exist across South East Asia. And in Nepal, Kirtipur Hospital and Tilganga Institute of Ophthalmology have both committed to powering their facilities on 100% renewable electricity. This will allow them to dramatically reduce their climate footprint while providing consistent care in Nepal where the electrical grid is unstable and prone to black outs.

China has formulated numerous regulations and plans at the national to provincial and municipal levels, focusing on energy conservation in public institutions within which healthcare is one of the major sectors. For instance, in 2016, Beijing Municipal Health and Family Planning Commission issued The Plan of Action for Energy Conservation and Carbon Reduction in the 13th Five-Year (2016-2020) Plan of Beijing Healthcare Institutions, setting a goal for the healthcare institutions' energy consumption reduction. In this context several Beijing hospitals have achieved significant carbon emission reductions by conducting green building retrofits, improving energy management and constructing new buildings by following new for Green Hospital Building hospital standards.

Climate action in the global supply chain: Some supply chain companies, such as Johnson & Johnson and Philips, have committed to 100% renewable electricity in their operations by 2050 or earlier. UNDP and Health Care Without Harm are developing criteria for low carbon health procurement that can mobilize health sector demand for zero emissions products.[61]

STUDY METHODOLOGY

The purpose of this study was to calculate the climate footprint of the global health care sector. A climate footprint covers emissions of carbon dioxide, methane and nitrous oxide gases associated with the activities of a sector or organization, and provides a more comprehensive measure of its contribution to climate change than a carbon footprint alone.

The method for calculating the climate impact of a studied system generally consists of multiplying the units of output of the system (i.e. quantity of activity it undertakes) by the amount of carbon associated with that unit of output (i.e. carbon intensity). This can be done at multiple scales ranging discrete product supply chains, whole organizations, sectors of the economy, or even geographic regions or nations.

Almost all activities in the global economy have some level of emissions associated with them. Economic systems such as health care are also highly interconnected with supporting sectors and through regional and multi-national supply chains. This means the real complication that comes with calculating a climate footprint, is that of sourcing data (activity and carbon intensity), tracking impacts through the value chain, and using appropriate accounting methods to accurately attribute impacts across connected systems.

Multi-Region Input-Output (MRIO) modelling offers a powerful methodology for doing this. It is a particularly useful tool since it avoids truncation errors that can occur due to insufficient data or as a consequence of the complexity and connectedness of supply chains.

MRIO harnesses economy Input-Output (IO) tables, which detail the trade flows and transactional quantities between sectors in an economy. Through combining national IO tables, a model for global trade split by sector and nation is constructed to create a MRIO table, capturing economic flows across borders and sectors. Such tables, paired with carbon emissions data, can then be used in environmentally extended MRIO (EE-MRIO) analyses to evaluate the links between economic activity and resource use, including greenhouse gas emissions.[17] With refinements to approach, EE-MRIO tables can be used to estimate the climate emissions of national, regional, and sectoral level activities of the economy.

A full description of methodology taken in this study including the MRIO approach, applied data and reporting structures can be found in Appendix B.

Definition of the health sector

To define study boundaries and create definition for what should be included in the assessment of the global health care sector carbon emissions, it was important to apply a definition for the sector. The World Health Organization's definition of the health sector was applied because it is commonly recognized and is aligned with useful published and available data. It defines the health sector as: "all organizations, institutions, and resources that are devoted to producing health actions. A health action is defined as any effort, whether personal health care, public health service or inter-sectoral initiative, whose primary purpose is to improve health."

Using the WHO definition as a foundation, the study combined this with the OECD health statistics reported in the System of Health Accounts (SHA) 2011 (co-published by the OECD, Eurostat, and WHO), and its allocation of health care activities across the global economy and the reported expenditures in those activities within the MRIO. This created a method for determining the scale of activities across the global health care sector and for producing climate footprint assessment outputs aligned with health care sector definitions.

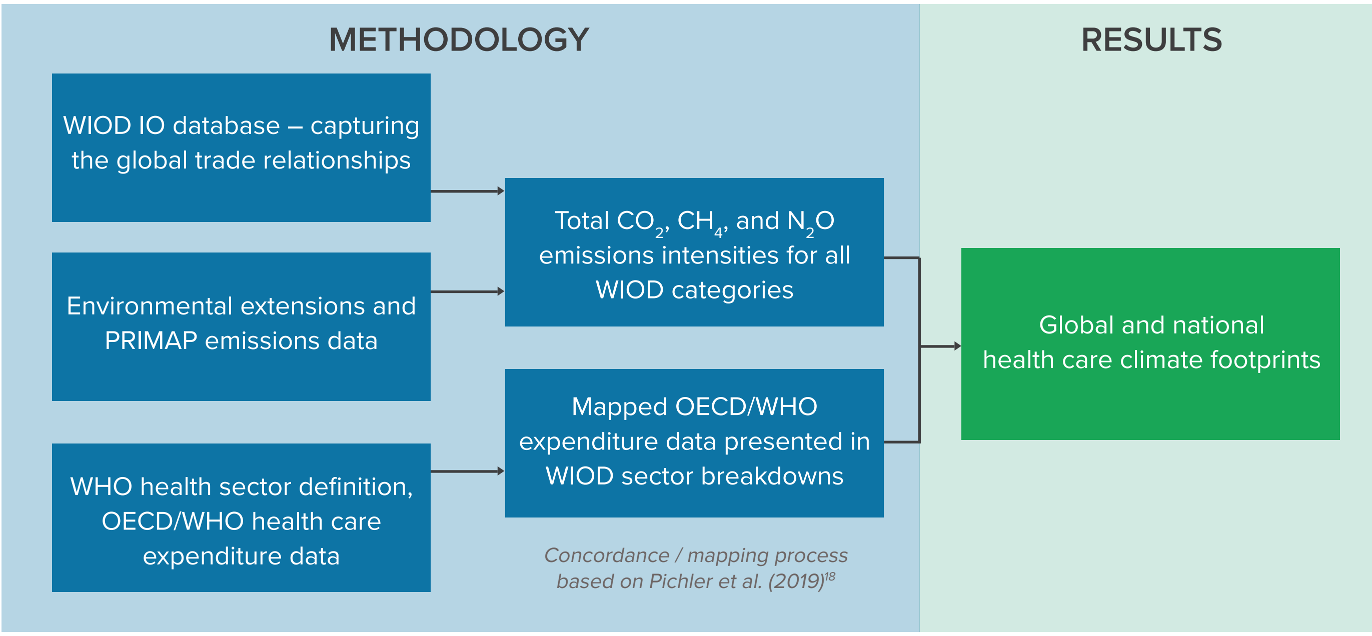

Figure 2: Methodology architecture for HCWH global health sector climate footprint

Databases, applied information, and method architecture

In developing the study method, a range of choices and database decisions were required. These are examined below covering the choice of MRIO database, environmental extensions, and national account expenditure data on health care. Taken together the methodology applied is summarized in Figure 2.

MRIO choice

This study was conducted using the World Input-Output Database (WIOD), a global MRIO model funded by the European Commission.[19] WIOD provides a full model of global trade, using a consistent 56-sector definition to describe the economies of 43 nations in detail, with an aggregated rest-of-world (ROW) category ensuring full global coverage. It is a highly regarded model, which has been widely used and validated in literature. WIOD was chosen over other database options due to its robust methodology, as well as its sectoral and geographical resolution.

Environmental extensions

The WIOD dataset provides a detailed environmental extension (EE) covering carbon dioxide emissions for all nations and sectors.[20] Unfortunately, other GHGs are not included in the EE, so a customised approach to including these emissions was required. The Greenhouse Gas Protocol lists six classes of greenhouse gas to be included in footprinting calculations:

- carbon dioxide
- methane
- nitrous oxide
- hydrofluorocarbons (HFCs)
- perfluorocarbons (PFCs)
- sulphur hexafluoride (SF6)

After carbon dioxide, the main contributors to global warming are methane and nitrous oxide. These gases were added to our methodology by allocating emissions reported in the PRIMAP emissions database to WIOD categories. This approach allowed us to incorporate virtually all global methane emissions and over 93% of global nitrous oxide emissions into the model. Collectively carbon dioxide, methane, and nitrous oxide accounted for over 98% of global GHG emissions in 2014.[21]

National expenditure data

The concordance process used to map expenditures is widely adopted and documented in the literature[12, 18]. Health expenditure data was used to ensure alignment between sector boundaries and the definition of the health care sector by WHO. National expenditure data was mapped onto WIOD categories using a concordance matrix between WHO and WIOD sector definitions. The theory behind this process is set out in the supplementary information to the study by Pichler et al.[22]. Detailed descriptions of the WIOD sector definitions[21] and of the WHO expenditure categories[23] were used to ensure consistent mapping of expenditures. Further detail on the health expenditure data for each nation and region in WIOD is available in Appendix B.

Presentation and reporting of results

The reporting of climate change impacts requires careful presentation so that the language used, and the systems and scopes applied are familiar to the intended audience and users of the information. The study reporting is framed by three general perspectives including the:

- World Input Output Database (WIOD) structure and economy sectors
- Structure of the WHO System of Health Accounts (SHA)
- Greenhouse Gas Protocol (GHGP) Scope 1, 2, and 3 categories

The GHGP scope categories are a widely applied and common framework (also in the health sector), for the allocation and reporting of GHG emissions of organizational and supply chain settings (Figure 3).

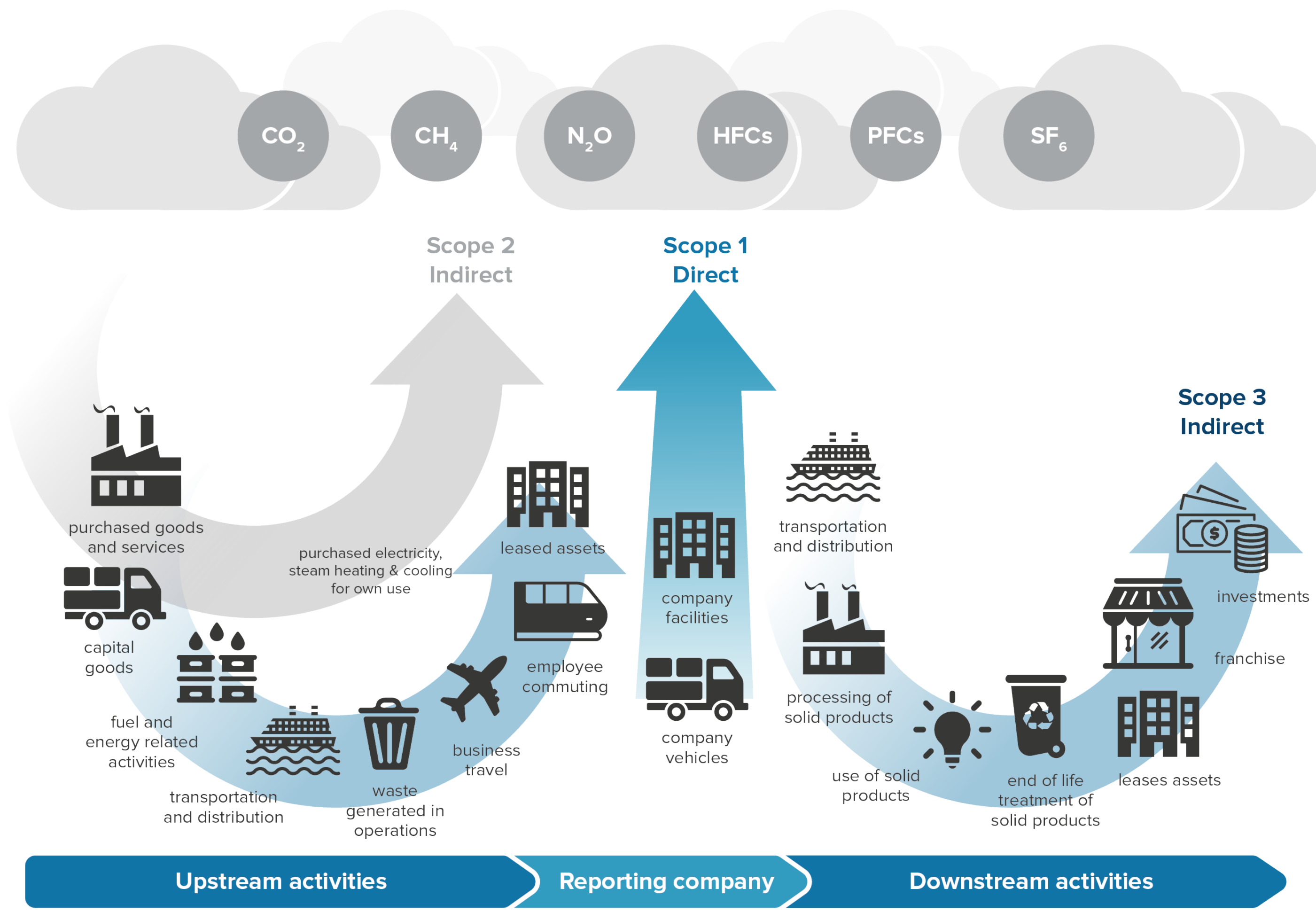

Figure 3: Greenhouse Gas Protocol Scopes 1, 2, and 3. (Source: Greenhouse Gas Protocol)

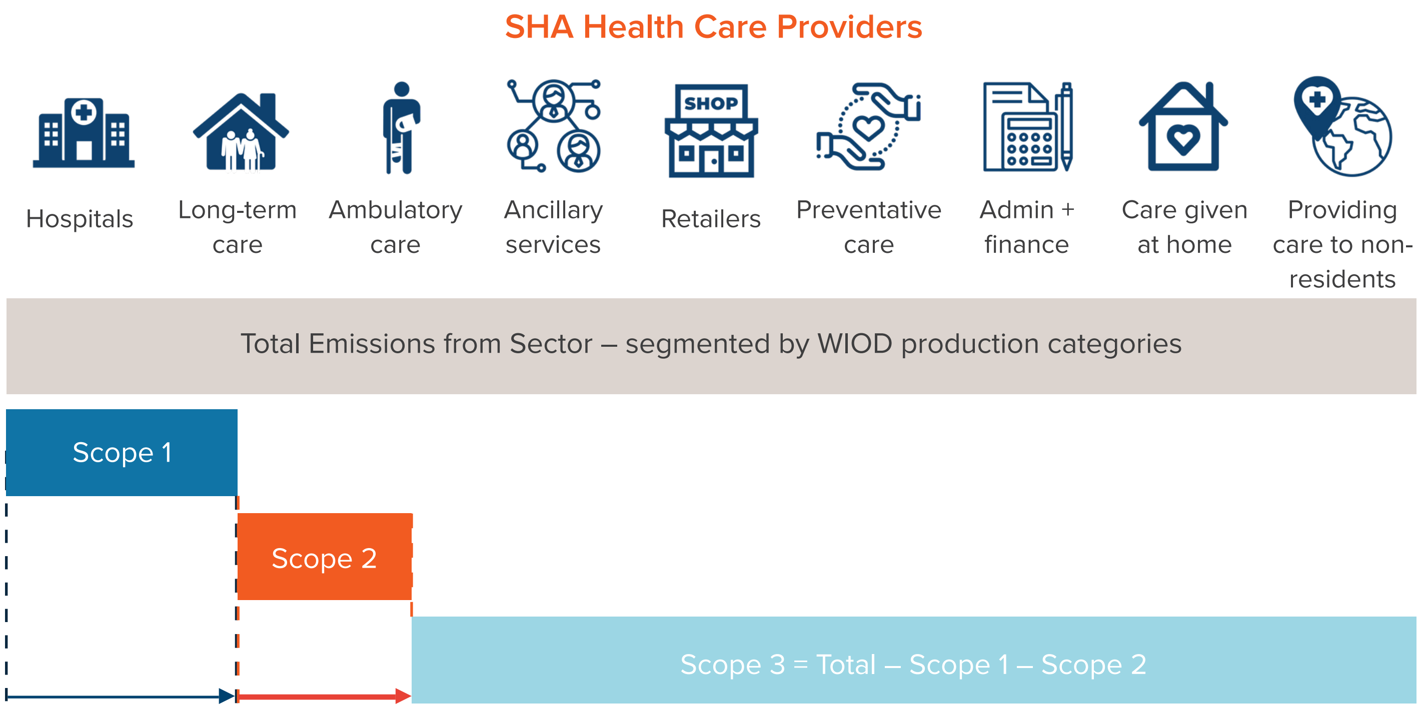

Figure 4: Approach taken for mapping emissions to GHGP Scope 1, 2, and 3 categories from the SHA and WIOD climate footprint assessment model

It was important to have a means to translate the study results based on the WIOD and SHA structures into a form consistent with the GHGP scopes. The approach developed for this framing of outputs involved a mapping of the SHA to the Scope 1, 2, and 3 categories through the economy sectors in the WIOD. Further description of this can be found in Appendix B, including a summary of how the GHGP scope definitions were interpreted into the health care sector's specific activities. A summary of this mapping is shown in Figure 4.

The audience for this paper is wide ranging and includes those across the health sector value chain. Its particular focus is to support the development of strategic and policy direction for health systems' climate action. In its findings, the reader will find results presented to both the WIOD and GHGP scopes. This should provide sufficient balance between understanding the key emission sources (via WIOD) and the reporting categories (via GHGP) commonly used for communicating and presenting climate action. A range of country- and region-specific summaries are also presented.

Metered-Dose Inhalers

Metered-Dose Inhalers (MDIs), typically used for the treatment of asthma and other respiratory conditions, use hydrofluorocarbons as propellants. These gases are highly potent greenhouse gases, with warming potentials between 1,480-2,900 times that of carbon dioxide.[26] As with anesthesia, global data on emissions from MDIs was not available, however, UNFCCC Annex 1 nations report data on emissions from this source.[27] For UNFCCC Annex 1 nations, emissions from MDI use totalled 6.9MtCO_2e, an additional 0.3% on top of the global health care footprint. The full global emissions from MDIs can be expected to be substantially greater than this figure, and while antiasthmatics are included on the WHO essential medicine list,[28] alternative delivery mechanisms to MDIs, such as dry powder based inhalers, are available which provide the same medicines without the high global warming potential propellents.

Study limitations

This paper aims to create an understanding of the climate footprint of the global health care sector and has used data sources and methods that prioritize the completeness of this over resolution. Therefore, the approach should not be expected to give results to a similar level of detail as footprints calculated for national health care systems, health care organizations, or individual health care facilities. A generalized summary of other limitations including data collection and reporting approaches include:

1. Alignment with previous studies: This paper is the first to estimate the climate impact of health care in all countries and across three major greenhouse gases. The closest comparable study[18] used a similar methodology, yet this paper differs in five key aspects (among others):
   a. It covers all countries, including an additional 25% of global GDP.
   b. It considers methane and nitrous oxide in addition to carbon dioxide emissions, equivalent to an additional 25% of global climate impact.
   c. Its modelling is based on WIOD MRIO database rather than Eora to facilitate comparison among countries.
   d. It uses a more granular approach to map health care spending for non-OECD countries, such as China and India.
   e. In the specific case of China, expenditure data was revised downward by 15% between the publication of Pichler et al.'s paper and this paper.

2. Spending data: The System of Health Accounts (SHA) spending data uses a consistent definition of health care and categorization of health care providers across countries.

3. Allocation of SHA spending data into WIOD economic sectors: The SHA health care provider categories do not align directly with WIOD economic sectors. The method of translating between the two requires some approximations based on detailed definitions of SHA and WIOD categories.

4. WIOD detail countries and the rest of the world (ROW): The WIOD database gives detailed information on 43 countries and combines the rest of the world into one aggregated sector. This means there is a loss of resolution into many countries. The ROW category – because it plays a balancing role within the model – also masks any irregularities in data reporting and sector definitions between the detail countries. This also means specific country data is lacking for all of Africa and the Middle East, as well as many low- and middle-income countries in Asia, Latin America, and the Caribbean.

5. Allocation of emissions footprint to GHGP scopes: It is challenging to disaggregate the MRIO-based approach to assessment into the Scope 1, 2, and 3 reporting structure, particularly regarding the sub-categories of Scope 3. Only partial perspectives to this are offered in the study. A structural path analysis is necessary to show full supply chain relationships with the model.

6. Nitrous oxide as anesthetics: The assessment is determined from data available for 31 countries under the UNFCCC reporting regime. These countries represent 15% of world population, 57% of GDP, and 73% of global health care expenditure. Due to this limitation, we report this data separately.

7. Fluorinated gases as anesthetics (desflurane, sevoflurane, isoflurane): Figures are derived from published research on atmospheric concentrations. The global warming potential is inferred from these measurements. It can be taken as a global footprint, but due to the different method for deriving the value, we report it separately.

8. Reporting year: This study considered emissions from the health care sector for 2014, the latest year available for the WIOD database. Progress has been made in the five years since then by health sector providers and their partners in decarbonising their activities. This is not as yet represented in the findings.