Quantifying the Carbon Footprint of a Multi-specialist Hospital in Ghana

Sheila Opoku Adjei[1*] and Daniel Tutu Benefoh[2]

[1]Centre for Climate Change and Sustainability Studies, University of Ghana, Legon

[2]Climate Change Unit, Environmental Protection Agency, Ghana

***Corresponding Author:** sheilaamponsah395@gmail.com

ABSTRACT

A carbon footprint is the amount of carbon dioxide released into the atmosphere as a result of the activities of a particular individual, organization, or community. Research undertaken indicates the global carbon footprint of the healthcare sector is estimated at 2 gigatons of CO_2e which is equivalent to the annual greenhouse gases produced by 514 coal power plants and if the global healthcare sector was a country, it would have been the fifth-largest emitter of greenhouse gases in the world. This supports the need to mitigate emissions from the healthcare sector in each country. In the healthcare sector, there has been a slow acceptance to take responsibility and mitigate greenhouse gas (GHG) emissions produced as a result of healthcare activities. This study quantified the carbon footprint of a multi-specialist hospital in Ghana and identified how the hospital can reduce its adverse impacts on the environment including achieving carbon neutrality. The total emissions from both direct and indirect sources of CO_2e quantified based on the Greenhouse Gas Protocol accounting standards, resulted in 465.79 tonnes of CO_2e for the year 2021. Regarding the major sources of greenhouse gas emissions from the hospital, the study revealed electricity consumption, generation of electricity from the backup power plant and the hospital fleet of vehicles as the sources of greenhouse gas emissions. The electricity consumption from the national grid contributed the most to emissions at 57% from the hospital's operations followed by the generation of electricity from an onsite power plant at 39%, diesel-powered vehicles at 3% and petrol-powered vehicles contributing 1% of the total GHG emissions of the hospital.

Keywords: Climate Change; Greenhouse gases emissions; Environment; Carbon footprint; Climate-smart healthcare

1.0 INTRODUCTION

The emphasis and concerns regarding global warming in the wake of climate change have increased with the release of the sixth Intergovernmental Panel on Climate Change assessment report calling for an immediate reduction in greenhouse gas (GHG) emissions in order not to reach a tipping point where the effects of climate change cannot be reversed (IPCC, 2021). The sixth

assessment report is "red coded" meaning the alarm bells are deafening and the evidence of climate is irrefutable (IPCC, 2021). Professor Christopher Rapley, former director of the British Antarctic Survey put forward four questions regarding climate change: Is the planet warming? Yes. Is it us? Yes. Does it matter? Yes. Must we do something? Yes. (Godlee, 2011). It has become urgent and apparent that humans answer these questions and take action about the warming globe.

Climate change refers to significant changes in global temperature, precipitation, wind patterns and other measures of climate that occur over several decades or longer (UNFCCC, 2011). According to the United Nations Framework Convention on Climate Change (UNFCCC), climate change is attributed directly or indirectly to human activity that alters the composition of the global atmosphere (United Nations Framework Convention, 1992). A carbon footprint is the amount of carbon dioxide released into the atmosphere as a result of the activities of a particular individual, organization, or community (Minoglou *et al*., 2017). With advocacy on climate change mitigation currently growing and gaining momentum in the world, it has become necessary for companies, organizations, businesses, entities, healthcare providers, and even individuals to measure how much carbon they emit through their day-to-day activities. This will enable them to develop strategies to reduce, avoid or offset their GHG emissions. The transition towards a low-carbon economy all over the globe requires data on how each sector of the economy contributes to the total CO_2 emissions (Minoglou *et al*., 2017).To begin the transition towards a low-carbon economy, each nation will require data on the contributions of different sectors to the total national CO_2e emissions. Hence the need for the health sector to measure its carbon footprint.

Research carried out by Health Care Without Harm in 2019 revealed the global carbon footprint of the healthcare sector is about 2 gigatons of CO_2e which is equivalent to the annual greenhouse gases produced from 514 coal power plants. The research concluded by stating that if the health care system in the world was a country it would have been the fifth-largest emitter of CO_2e as is responsible for 4.4% of total global emissions. This supports the need to mitigate emissions from the healthcare sector in each country. To be able to reduce the emissions, hospitals need to quantify their carbon footprint and know which activities contribute immensely to the generation of greenhouse gas emissions and take steps to manage their emissions. The paper aimed to estimate the total annual greenhouse gas emissions footprint of a multi-specialist hospital for one year and identify the major sources of greenhouse gas emissions of the hospital. Emissions quantification from healthcare sectors in the UK, US, Australia and other countries emphasize the need for the healthcare industry to place importance on the mitigation of GHG emissions to reduce the harmful impact of their activities on the environment. Studies in Canada, the UK, US suggest that operation theatres were largest

sources of GHG emissions due to the use of anaesthetic gas and energy consumption (Karliner *et al*., 2019).

In a recent study by Booth, 2022 the healthcare sector services have avoided responsibilities toward the environment in its bid to provide healthcare services. As of 2022, only six countries had measured their healthcare carbon footprint in the world (Booth, 2022). While the Organisation for Economic Co-operation and Development countries have had their healthcare carbon footprint modelled by researchers as well as countries such as China and India (Booth, 2022). Nankai *et al*, 2020 carried out a trend analysis of domestic GHG emissions from Japanese healthcare expenditure. Their result showed that in 2011 carbon emissions in Japan from the healthcare sector were 62.5MTCO_2e (4.6% of the national total) and rose to 72.00MTCO_2e in 2015. An Australian healthcare emissions study conducted by Malik *et al*, 2018 was collected using healthcare expenditure from the Australian Institute of Health and Welfare. The findings showed the healthcare sector emission was 7% of Australia's entire CO_2e which is 35,772 KtCO_2e (Malik *et al*., 2018). According to Collins and Wolff, 2021, major sources of hospital greenhouse gas emissions are hospital fleet of vehicles, power generation, waste anaesthetic gas and refrigeration.

"Climate-smart healthcare" has become a collective term for measures taken to build resilience to climate change and reduce greenhouse gas emissions in our day-to-day operations of healthcare facilities (Karliner & Manogaran, 2021). Therefore, put simply, climate-smart healthcare is a low-carbon and resilient healthcare system. The goals of climate-smart healthcare according to Health Care Without Harm are to decarbonize the healthcare sector (mitigate), increase resilience to climate change (adaptation and resilience) and increase climate advocacy by healthcare leaders. There is a pressing need globally to ascertain how the healthcare sector impacts the environment due to the potential adverse impact of their activities. Extensive research work in this field will bring awareness and education to healthcare professionals and encourage hospitals to be environmentally conscious in their activities and influence their patients and society to do the same. Through the findings of the research, hospitals will know actions they can take to be carbon neutral and guide future actions to be taken to reduce emissions.

Records of temperature rise since 1850 show the temperature of the globe has risen by 1.1◦ Celsius, and in the last four decades, temperatures have been warmer than in the preceding decades (The Royal Society, 2021). Scientists have been able to use models to reconstruct past temperatures before pre-industrial times, and with comparison to current global temperatures, it is indicative of a rising temperature since 1850 (Harmeling, 2018). A growing concern about climate change globally is the threat to human health and well-being, as well as the serious impacts and potential disruption to all economic sectors and supply chains, such as trade, tourism, agriculture, forestry, and fisheries

(Bozoudis et al., 2022). As of 2021, the global GHG emissions concentration of the atmosphere was estimated at 410 ppm, a record high in the last 800,000 years (The Royal Society, 2021). The presence of high concentrations of CO_2 emissions and other GHG causes an amplified greenhouse effect which leads to global warming with resultant effects such as severity and frequency of floods, drought, heat waves, increases in temperature, variation in precipitation, sea level rise, melting of polar ice and permafrost (IPCC, 2021).

The environmental impact of the delivery of medical and hospital care, which generates greenhouse gas emissions, must be investigated thoroughly to enable the design and implementation of effective mitigation actions and measures (McAlister and Barratt, 2022). Immersed in the healing of patients, hospitals use enormous amounts of natural resources and generate tons of waste daily, including the consumption of huge amounts of electricity (Karliner et al., 2019). This translates to increases in greenhouse gas emissions and air quality issues that have the potential to result in more patient admissions. Research carried out by Health Care Without Harm in 2019 revealed that the global carbon footprint of the healthcare sector is about 2 gigatons of CO_2e, which is equivalent to the annual greenhouse gases produced from 514 coal power plants. The research concluded by stating that if the health care system in the world was a country, it would have been the fifth-largest emitter of CO_2e as it is responsible for 4.4% of total global emissions. This supports the need to mitigate emissions from the healthcare sector in every country.

To be able to reduce the emissions, hospitals need to quantify their carbon footprint and know which activities contribute immensely to the generation of greenhouse gas emissions and take steps to manage the situation hence the need for this study. The researcher did not obtain any research carried out to quantify the carbon footprint of a hospital or the health sector in Ghana. This study sought to fill this gap. This study is a novelty and provides the basis for further research in the quantification of greenhouse emissions in hospitals and the healthcare sector in Ghana. The slow response of the health sector in mitigating greenhouse gas emissions is equally a challenge that must be dealt with by quantifying emissions from hospitals that will help hospital leadership make informed decisions about climate change mitigation. The healthcare sector has a responsibility to respond to global warming mitigations through the reduction of its emissions because it is indisputable that the sector is a large emitter of greenhouse gases hence this study (Storz, 2018).

Secondly, one important question that must be answered globally about healthcare service is “Is the healthcare sector green”? Due to the additional costs, the healthcare industry is generally lacking in environmentally sustainable practices. As a result, current healthcare practices continue to adversely impact the environment via a lot of activities such as waste generation, hospital travel, paperwork and the

operation of incinerators (Eckelman & Sherman, 2016). The study intended to bring to the attention of healthcare facilities in Ghana in ways they impact the environment and offer recommendations on how healthcare facilities can be environmentally conscious in their work delivery.

Objectives of the Study

1. To estimate the total annual greenhouse gas emissions footprint of a multi-specialist hospital.
2. To identify the major sources of greenhouse gas emissions by sources and removals by sinks of the multi-specialist hospital.
3. To identify ways the hospital can minimise its adverse environmental impacts and be environmentally conscious in its work delivery.

Research Questions

1. What are the estimated total annual greenhouse gas emissions of the multi-specialist hospital?
2. What are the major sources of greenhouse gas emissions/ removals of multi-specialist hospital
3. How can a multi-specialist hospital minimise its adverse environmental impacts and be environmentally conscious in its work delivery?

1.1 Sources of greenhouse gas emissions in the healthcare delivery sector

Health facilities require energy 24 hours for 365 days to heat water, lighting, space heating, cooling ventilation, steam production and other clinical procedures. While using energy intensively for patients' comfort, significant greenhouse gases are equally emitted with each activity (Tufail, 2008). MacNeil et al., 2017 discovered theatres' energy consumption is three to six times more than the entire hospital's energy. Operating theatres are known to contribute significantly to GHG. In addition, incineration produces carbon monoxide, carbon dioxide, nitrous oxide and sulphur dioxide, some of which are GHG and toxic gases (Tufail, 2008).

Further to this, Gadani and Vyas, 2010 indicate that one way the healthcare sector contributes to global warming is through the use of anaesthetic gases. This is a result of volatile gases such as nitrous oxide used in anaesthetic gases. When patients exhale, anaesthetic gases are vented out from the medical room as waste gases and remain in the atmosphere for a long time. Nitrous oxide has a warming potential by trapping outgoing energy in the atmosphere causing global warming (Gadani & Vyas, 2010). Hospitals use appliances such as MRI machines, CT scanners, linear accelerators, laboratory reagents, pharmaceutical equipment, medical coolants and air conditioners that operate with refrigerants. Refrigerants are a known source of greenhouse gases, such as hydroflurocarbons that contribute to global warming (Abas et al., 2018). Burning fossil fuels for patient and staff travel is a source of GHG emissions for hospitals (Karliner et al., 2019). Activities that contribute to greenhouse gas (GHG) emissions in healthcare delivery include:

- Hospital Fleet of Vehicles
- Food sourced from long transport routes

instead of locally sourced food
- Highly processed foods and packaged foods require burning fossil fuels or petroleum-based fuels in production activities.
- Use of papers and office supplies
- Use of electricity for air conditioners, hospital equipment, lighting etc
- Use of energy for cooking and catering
- Air travels
- Inhaled anaesthetic gases from healthcare facilities are a source of greenhouse gas emissions
- Water usage
- Use of refrigerants in some hospital equipment and HVAC equipment
- Waste management (Incineration)
- On-site boilers and generators
- Hospital supplies and consumables
- Construction works

(Adapted from Karliner et al., 2019; MacNeil et al., 2017)

1.2 Climate-Smart Healthcare

It is the primary focus of every healthcare system to offer improved healthcare to its population and build resilience to climate events (Karliner & Manogaran, 2021). Having stated above, "climate-smart" has become a collective term for measures taken to build resilience to climate change and reduce greenhouse gas emissions in our day-to-day operations of healthcare facilities. Working on these two measures hand-in-hand is important to offer comprehensive healthcare in the face of climate change challenges (Karliner & Manogaran, 2021). Therefore, put simply, climate-smart healthcare is a low-carbon and resilient healthcare system.

The WHO explains climate-resilience healthcare to be a healthcare system which is capable of anticipating, responding and coping with shocks and stress that come with climate change (Health Care Without Harm, 2021). As the population grows with the occurrence of other novel infectious diseases such as Ebola and COVID-19, the world experienced failures and insufficiencies in the healthcare system in many countries (Health Care Without Harm, 2021). Climate change is expected to increase the transmission and frequency of vector-borne diseases such as malaria and dengue fever (World Health Organization, 2015). It is expected that there will be frequent outbreaks of water-borne diseases such as diarrhoea and cholera due to extreme weather events such as floods and droughts. Climate change is likely to increase heat-related deaths among some populations as well as mental health challenges (World Health Organization, 2015). Consequently, healthcare facilities must assess their vulnerabilities as the first step to building resilience to the climate crisis (Karliner & Manogaran, 2021). This includes vulnerability assessment of their infrastructure and communities. There should be a collaboration between the meteorological departments and healthcare givers to prepare for any eventualities (Karliner & Manogaran, 2021). Where there exists some form of weakness, steps should be advanced to

strengthen those areas and mitigate against any vulnerabilities. The goals of climate-smart healthcare, according to the Health Care Without Harm are to decarbonise the healthcare sector (mitigate), increase resilience to climate change (adaptation and resilience) and increase climate advocacy by healthcare leaders. According to Collins & Wolff, 2021, it is an undeniable fact that the healthcare sector is the only sector that has an opportunity to use its ethical and political influence to create ecologically sustainable, equitable and healthy communities. They can take actions that will ensure the mitigation of GHG while building resistance to climate change extreme events. Actions such as tree plantations, carpooling and the use of clean energy in their operations.

In addition, the sector can equally take action to reduce waste by using recycled products and recycling their waste to save the environment. Other actions from healthcare leadership, such as educating patients and colleagues on climate change, and emergency preparedness plans, and establishing or joining a green network for large-scale planning efforts on climate change are encouraged. Quitmann et al., 2022 investigated hospital stakeholder perception of hospitals' contribution to GHG emissions and the sense of responsibility for or mitigation of GHG emissions. The result showed hospital stakeholders (patients and employees) felt they had less responsibility to mitigate climate change. However, they perceived providing the best medical care to be their top priority and were concerned that patients' health could be jeopardised by climate change mitigation measures (Quitmann et al., 2022).

1.3 Healthcare, A Major Contributor to Climate Crisis

To reduce GHG emissions globally, each country must know the contributions each sector of its economy makes to greenhouse gas emissions at the national level. In the UK, research carried out by the National Health Service (NHS) showed that 4% of the entire emissions in the UK are attributed to the healthcare sector (NHS, 2020). The studies quantified emissions from prescribing drugs and health delivery travel emissions (NHS-UK). In Japan, the carbon footprint for healthcare services was quantified for the period from 2011 to 2015 by Nansai et al., 2020, using input-output analysis. It was observed that the healthcare carbon footprint increased from 62.5 Mt CO_2e in 2011 to 72.00 Mt CO_2e in 2015. This is a rise of 15%, with major drivers of healthcare emissions in Japan being the purchase of pharmaceuticals and electricity consumption by the healthcare sector (Nansai et al., 2020). Eckelman and Sherman, 2016 estimated emissions, directly and indirectly, attributable to the US healthcare sector. The economic input-output life cycle assessment modelling was employed based on data from National Health Expenditure for the decade 2003-2013. Findings from the study showed that GHG emissions from the US health sector amounted to 665 million Mt CO_{2e} and constituted

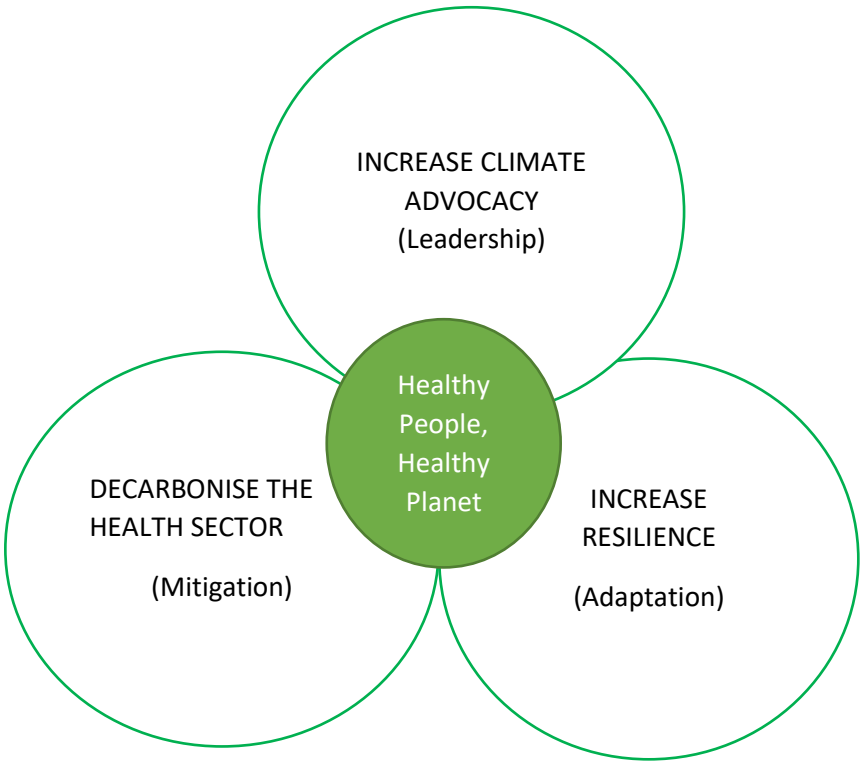

Figure 1: Goals of Climate-Smart Healthcare

Source: Author's Construct, 2022 (Adapted from Collins and Wolff, 2021, Health Care Without Harm)

and constituted 9.8% of the total national emissions of the United States. The study further indicated that if the US health sector was a country, it would rank 13th at the global level for greenhouse emissions. The majority of healthcare GHG emissions in the USA are associated with the supply of energy, healthcare goods and healthcare services (Eckelman & Sherman, 2016).

Staff travel is a significant contributor to GHG emissions in hospitals (Tomson, 2015). In addition, a hospital building is seen as unfit for purpose if it does not support the conservation of energy and water. In essence, such hospital buildings were not constructed with the protection of the environment in mind making them environmentally unfriendly (Tomson, 2015). Procurement of pharmaceuticals in the UK is responsible for 22% of the entire carbon footprint of the UK's health sector. And 75% of the UK's health sector's carbon footprint is generated as a result of the production of healthcare goods and services (Tomson, 2015). The average carbon footprint for primary healthcare practice in Switzerland was quantified by Nicolet et al., 2022 from ten private practices in 2018. The result revealed that more than half of the carbon footprint quantified for the primary

healthcare practices came from mobility both for patients and hospital staff (Nicolet et al., 2022).

1.4 Climate and Health Profile of Ghana

According to a country profile report for Ghana by the World Health Organisation, in a scenario with high emissions, the mean annual temperature in Ghana is projected to rise by about 4.8◦ Celsius between 1990 to 2100 (World Health Organization, 2015). However, the temperature rise will be limited to 12◦ Celsius in the emissions decrease scenario. In a scenario where emissions are high and with a lack of investment in adaptation measures for Ghana, about 241,900 people are projected to be adversely affected by flooding as a result of sea level rise in the next fifty to seventy years. If there is a good investment into adaptation, such as raising dikes, about 200 people instead may be affected by floods (World Health Organization, 2015). Frequent floods can affect food cultivation and freshwater salinisation, which may affect water availability for livestock and increase water-borne disease outbreaks and vector distribution within an area (World Health Organization, 2015). Ultimately some populations affected by floods will be traumatised and displaced and could lose their livelihoods according to the WHO country profile report on climate change and health for Ghana.

Heat-related deaths among the elderly aged 65 and above are projected to increase to 70 deaths per 100,000 persons annually by 2050. This is compared to the period between 1961 to 1990, which saw under 2 deaths per 100,000 persons annually due to heat-related deaths is quite on the high side (World Health Organization, 2015). According to Codjoe et al., 2020, heat stress could affect labour productivity for outdoor workers. Climate change is projected by WHO to put over 58 million people at risk of malaria by 207,0 as population growth in 2070 could lead to an increased population at risk of malaria (World Health Organization, 2015). Codjoe et al., 2020 investigated Ghanaian health system vulnerabilities associated with flooding and extreme heat, along with strategies for resilience building by healthcare service providers in Tamale and Accra. Their findings revealed that healthcare buildings are in poor conditions with frequent power outages and reduced access to healthcare by residents are some of the challenges that make the healthcare system vulnerable and difficult to deliver on their mandate in the face of climate change extremities such as flooding and extreme heat. Since 2011, continuous blackouts with unreliable power supply from the national grid have posed a challenge for the Ghanaian health sector and could be magnified by the extremities of climate change.

2.0 METHODS

A case study of a multi-specialist hospital in Ghana was undertaken. A mixed-Method Approach was employed in the study. The qualitative research method was employed for interviewing hospital staff. Purposive sampling was employed for selecting hospital staff for interviews. The staff that were

interviewed were the service quality manager, safety, health and environment manager and the supply chain manager. The multi-specialist hospital under study is one of Ghana's biggest private medical facilities. Their services cover the areas of obstetrics/gynaecology, ophthalmology, orthopaedics, physiotherapy, plastic surgery, urology, dietetics, ear/nose/throat, haematology/sickle cell, paediatrics, dermatology and primary healthcare. The hospital operates from five locations in Ghana referred to in this study as Site 1, Site 2, Site 3, Site 4 and Site 5. Institutional express consent for carrying out the research was obtained from the Service Quality Department of the hospital. Data from Site 5 of the hospital operation were excluded from this study as the site was not in operation in 2021 which is the year under study.

Greenhouse Gas Protocol Corporate Accounting and Reporting Standard Methodology (Revised Edition) were used for the quantification of the carbon footprint of the hospital. This protocol is the most widely used standard for mandatory and voluntary GHG reports and is compatible with other international GHG standards such as ISO 14064. Based on the Greenhouse Gas Protocol, a comprehensive greenhouse gas inventory was performed for the four sites of the hospital. The operational boundary of the hospital was defined as the office, wards, detention room, theatre, pharmacy and canteen. The Greenhouse Gas Protocol by the World Resources Institute defines three scopes of emissions for accounting and reporting carbon dioxide equivalent (CO_2e) emissions. Scope 1 emissions cover direct emissions from within an organisation's boundary of which the organization has control. Scope 2 emissions include indirect emissions due to the consumption of electricity, while scope 3 emissions encompass all other indirect emissions related to the organisation's activities but not under the organisation's control. Greenhouse Gas Protocol Corporate Accounting and Reporting Standard Methodology (Revised Edition) states only scope 1 and scope 2 emissions of an orgsanisation be included in the carbon footprint of that specific organization.

2.1 Greenhouse Gas Emissions Quantification Procedure

The first step in the measurement of the carbon footprint of the hospital involved a comprehensive greenhouse gas inventory of all the activities that contribute to emissions/removals of GHG through the hospital's activities. Greenhouse gas protocol recommends quantification of six (6) classes of GHG, namely carbon dioxide, methane, nitrous oxide, hydrofluorocarbons - HFCs, perfluorocarbons -PFCs, sulphur hexafluoride- SF_6 (WBCSD & WRI, 2012). In this study, the gas types quantified from the activities of the hospital were three in all; carbon dioxide (CO_2) nitrous oxide (N_2O) and methane (CH_4) from the burning of diesel and petrol through the hospital's power generation and road transportation. Emissions from the use of electricity from the national grid were included to arrive at the total greenhouse gas emissions for the hospital.

Regarding sources of removal of greenhouse gases by the hospital, the trees in the hospital were counted and measured but the contribution of the trees to the removal of greenhouse gases from the atmosphere was negligible and thus was not included in the quantification of the footprint of the hospital.

The next step involved the collection of activity data in the form of the quantity of fuel consumed for combustion purposes. The activity data were multiplied by the emission factors for each gas type. The results were then multiplied by the global warming potential of each gas type to ensure all emissions were carbon dioxide equivalent (CO_2e). The Global Warming Potential (GWP) allows comparisons of the global warming impacts of different gases and their ability to warm the globe relative to carbon dioxide over 100 years (GHG Protocol, 2016). GWPs are multipliers applied to greenhouse gases such as methane (CH_4) and Nitrous Oxide (N_2O) to equate the impact they have on the earth's temperature with that of Carbon Dioxide (IPCC, 2021). According to the IPCC AR4 100-year GWPs, CO_2 is 1, CH_4 (fossil fuel based) is 25, and N_2O is 298(GHG Protocol, 2016). The equation below was used for the quantification of emissions.

GHG Emissions = Activity Data X Emission Factor
E= AD x EF

Activity data is the data on the activity that affects greenhouse gas emissions/removal, and the emission factor indicates the quantity of GHG emitted or removed during GHG-producing activity. In other words, it is a coefficient that quantifies the emissions or removals of a gas per unit activity (IPCC, 2021). Kindly refer to Table 1 for the activity data used in the quantification of the carbon footprint for the hospital.

Table 1: Activity Data for 2021

Activity Data		
Sources	**Activity**	**Units**
Hospital Ambulance (Diesel)	3230.06	L
Hospital Pickup (Diesel)	3636.00	L
Hospital Vehicles (Petrol)	2407.18	L
Electricity	659319.04	kWh
Power Plant (Diesel)	74916	L

3.0 RESULTS AND DISCUSSIONS

Greenhouse gas emissions from the hospital operations for 2021 resulted in 465.79 tCO_2e. Kindly refer to Table 2 for the breakdown. Table 3 shows the main source of direct emissions generated from the use of diesel power plants for electricity generation onsite. With regard to the total hospital emissions, electricity consumption from the national grid contributes the most total emissions at 57% followed by the generation of electricity from an onsite power plant at 39% diesel-power vehicles at 3% and petrol-powered vehicles contributing 1% of the total CO_2e

emissions of the hospital. Kindly refer to Figure 2.

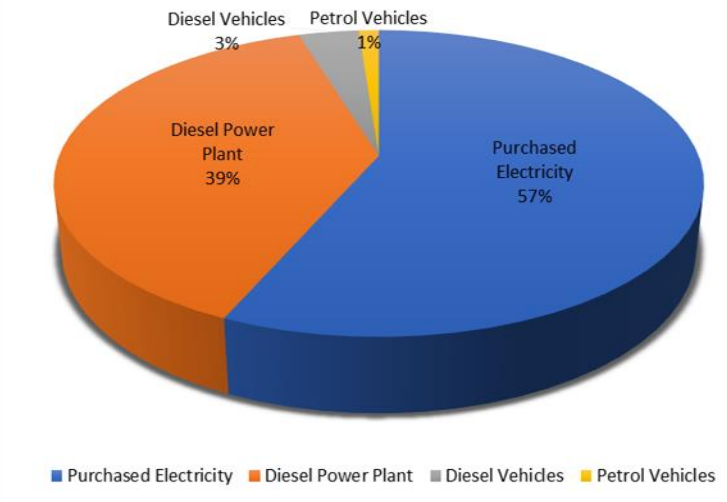

Figure 2: Total CO_2e by Activity for 2021

Table 2: Annual greenhouse gas emissions from hospital operations for 2021

						CO_2		CH_4		N_2O		
Activities	**Quantity**	**Unit**	**Amount**	**Unit**	**EF**	**Unit**	**EF**	**Unit**	**EF**	**Unit**	**Total Emissions Tonnes CO_2 Equivalent**
Purchased electricity	659,319.04	kWH	659.32	MWh	0.4	tCO_2/MWh					263.73
Diesel Power Plant	74,916	litres	2.42	TJ	74100	tCO_2/TJ	3	tCH_4/TJ	0.6	tN_2O/TJ	179.94
Diesel Vehicles	6,866.1	litres	0.22	TJ	74100	tCO_2/TJ	3.9	tCH_4/TJ	3.9	tN_2O/TJ	16.58
Petrol Vehicles	2,407	litres	0.078	TJ	69300	tCO_2/TJ	33	tCH_4/TJ	3.2	tN_2O/TJ	5.54
					Total Emissions						465.79

CO_2e was calculated using 100-year Global Warming Potential values of 1 for carbon dioxide, 25 for methane and 298 for nitrous oxide. EF-Emission Factor

Table 3: Emissions from Direct and Indirect Sources

Operational Emissions Category	Activities	Total Emissions Tonnes CO_2 Equivalent	Percentage of Total Hospital Emissions (%)
Indirect Emissions Source	Purchased Electricity	263.73	57
Direct Emission Sources	Diesel Power Plant	179.94	39
	Diesel Vehicles	16.58	3
	Petrol Vehicles	5.54	1
Total Emissions		465.79	100.00

The total emissions from both direct (scope 1) and indirect sources (Scope 2) of CO_2e quantified resulted in 465.79 tonnes of CO_2e for the year 2021. The activity that contributed the most to the direct source of emissions from the hospital was the use of a backup power plant when power from the national grid was unavailable. Overall, the source of activity that contributed the most to the hospital's emissions in 2021 was the consumption of electricity from the national grid totaling 57 % of total hospital emissions.

Regarding the major sources of greenhouse gas emissions from the hospital, the study revealed electricity consumption, generation of electricity from the backup power plant and the hospital fleet of vehicles as the sources of emissions. The results indicate the carbon footprint annually, although based on activity data for 2021. However, it indicates the areas to concentrate on to reduce emissions. Additionally, the tonnes of emissions that can be removed from the atmosphere for the hospital to be carbon neutral can be determined from the carbon footprint measured over a considerable period.

4.0 CONCLUSION

The healthcare industry aims to heal and do no harm and must therefore transcend beyond this by ensuring quality care for its patients in a sustainable environment. The study challenges healthcare practitioners to take leadership roles in climate change mitigations and become advocates for the reduction of emissions as well as ensuring sustainability in their operations. Hospital should

Hospitals should reduce their reliance on fossil-powered backup power plants and instead rely on a backup power plant that uses renewable energy such as solar energy. Ultimately, hospitals should set a target year by which time their entire operations would be powered by 100% clean energy such as solar energy.Tree-planting programs should be encouraged in the healthcare sector. Tree plantations help remove greenhouse gases from the atmosphere. Hospitals should set a target year where they hope to become carbon neutral which means balancing emissions of carbon dioxide with its removal from the atmosphere. Telemedicine (eHealth) is recommended to reduce emissions from patients commuting to the hospital for medical care, especially for patients who have chronic diseases. This will help reduce emissions from transportation (burning of fossil fuels) and reduce the cost of providing resources (energy, hygiene consumables, water etc.) to patients who visit the hospital daily.

The use of electric vehicles is recommended for transporting patients to bigger health facilities and electric motorbikes to deliver medication to patients who are attended to via electronic means to ensure the reduction of the carbon footprint of the hospital.

FUNDING SUPPORT

The author did not receive funding for this work.

REFERENCES

Abas, N., Kalair, A. R., Khan, N., Haider, A., Saleem, Z., & Shoaib, M. (2018). Natural and synthetic refrigerants, global warming : A review. *Renewable and Sustainable Energy Reviews*, *90*(August 2016), 557–569. https://doi.org/10.1016/j.rser.2018.03.099

Abas, N., Kalair, A. R., Khan, N., Haider, A., Saleem, Z., & Shoaib, M. (2018). Natural and synthetic refrigerants, global warming : A review. Renewable and Sustainable Energy Reviews, 90(August 2016), 557–569. https://doi.org/10.1016/j.rser.2018.03.099

Booth, A. (2022). Carbon footprint modelling of national health systems : Opportunities, challenges and recommendations. February, 1–9. https://doi.org/10.1002/hpm.3447

Eckelman, M. J., & Sherman, J. (2016). Environmental Impacts of the U.S. Health Care System and Effects on Public Health. 1–14. https://doi.org/10.1371/journal.pone.0157014

Gadani, H., & Vyas, A. (2010). Anesthesia : Essays and Researches Anesthetic gases and global warming : Potentials , prevention and future of anesthesia. 5–10. https://doi.org/10.4103/0259-1162.84171

GHG Protocol. (2016). Global Warming Potential Values. Greenhouse Gas Protocol, 2014(1995), 1–4. https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%28Feb 16 2016%29_1.pdf

Harmeling, S. (2018). Climate change impacts. Routledge Handbook of Human Rights and Climate Governance, 90–109. https://doi.org/10.4324/9781315312576-7

Health Care Without Harm. (2021). Climate Smart Healthcare.

IPCC. (2021). Climate Change 2021 The Physical Science Basis Summary for Policymakers Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. In Climate Change 2021: The Physical Science Basis.

Karliner, J., & Manogaran, S. (2021). Climate-smart healthcare. Climate Change and the Health Sector, 119–130. https://doi.org/10.4324/9781003190516-16

Karliner, J., Slotterback, S., Boyd, R., Ashby, B., & Steele, K. (2019). Health Care's Climate Footprint - How the Health Sector Contributes to the Global Climate Crisis and Opportunities for Action - Green Paper Number One in the Climate-Smart Health Care Series. Health Care Without Harm, September. https://noharm-uscanada.org/ClimateFootprintReport

Malik, A., Lenzen, M., McAlister, S., & McGain, F. (2018). The carbon footprint of Australian health care. The Lancet Planetary Health, 2(1), e2–e3. https://doi.org/10.1016/S2542-5196(17)30180-8

Minoglou, M., Gerassimidou, S., & Komilis, D. (2017). Healthcare waste generation worldwide and its dependence on socio-economic and environmental factors. Sustainability (Switzerland), 9(2). https://doi.org/10.3390/su9020220

Nansai, K., Fry, J., Malik, A., Takayanagi, W., & Kondo, N. (2020). Carbon footprint of Japanese healthcare services from 2011 to 2015. Resources, Conservation and Recycling, 152(September 2019), 104525. https://doi.org/10.1016/j.resconrec.2019.104525

NHS, T. (2020). THE NHS : CARBON FOOTPRINT Sources of NHS carbon emissions. 1–5.

Nicolet, J., Mueller, Y., Paruta, P., Boucher, J., & Senn, N. (2022). What is the carbon footprint of primary care practices? A retrospective life-cycle analysis in Switzerland. Environmental Health: A Global Access Science Source, 21(1), 1–10. https://doi.org/10.1186/s12940-021-00814-y

Quitmann, C., Sauerborn, R., Danquah, I., & Herrmann, A. (2022). ' Climate change mitigation is a hot topic , but not when it comes to hospitals ': a qualitative study on hospital stakeholders ' perception and sense of responsibility for greenhouse gas emissions. 1–7. https://doi.org/10.1136/medethics-2021-107971

Ramde, E. W., Rummeny, S., Schneiders, T., Waffenschmidt, E., Meilinger, S., Chaaraoui, S., & Bebber, M. (2020). Planning of sustainable and stable micro grids for Ghanaian hospitals with photovoltaics. October 2021, 1–9.

Storz, M. A. (2018). A Practical Guide for Physicians and Health Care Workers to Reduce Their Carbon Footprint in Daily Clinical Work. The Permanente Journal, 22, 1–3. https://doi.org/10.7812/TPP/17-145

The Royal Society. (2021). Climate change and global warming: Impacts on crop production. Genetically Modified Plants, 283–296. https://doi.org/10.1016/b978-0-12-818564-3.09991-1

Tomson, C. (2015). HOSPITAL INFRASTRUCTURE Reducing the carbon footprint of hospital-based care. Future Hospital Journal, 2(1), 57–62. www.supplychain.nhs.

Tufail, M. (2008). Heavy metal pollution from medical waste incineration at Islamabad and. 90(2), 77–81. https://doi.org/10.1016-/j.microc.2008.03.010

UNFCCC. (2011). Climate change science - the status of climate change science today. United Nations Framework Convention on Climate Change, February 2011, 1–7. https://unfccc.int/files/press/backgrounders/application/pdf/press_factsh_science.pdf

United Nations Framework Convention. (1992). 62220.

WBCSD, & WRI. (2012). A Corporate Accounting and Reporting Standard. Greenhouse Gas Protocol, 116.

World Health Organization. (2015). Climate and Health Country Profile - Ghana. United Nations Framework Convention on Climate Change, 1–8. https://www.who.int/globalchange/en/