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Travel-associated carbon emissions of patients receiving cancer treatment from an urban safety net hospital

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ABSTRACT

Background: Healthcare transportation, particularly the transportation of patients to access healthcare services, is a significant source of carbon emissions. This study aims to estimate the carbon emissions of patient transportation among patients receiving cancer care at an urban community safety net hospital.

Materials and Methods: We conducted a retrospective study of patients seen at the oncology clinic of an urban community safety net hospital between 1 July 2022 and 30 June 2023. Patients with at least one in-person visit in 1 year, documented home addresses, and oncologic diagnoses were included in the study. The distance between each patient's home address and the hospital was calculated using the Google Map API key and a macro to calculate distance in metres. The total estimated carbon emissions were calculated using the EPA equivalencies calculator. The primary outcome was carbon emissions from patients' round-trip travel from home to hospital.

Results: From 1 July 2022 to 30 June 2023, 13,970 visits were made to the oncology clinic. Of these, 8,235 visits made by 1,080 patients met the criteria for inclusion in the final analysis. Of the 8,235 visits recorded, 5,095 (61.8%) were follow-up/laboratory visits. The 1,080 patients who attended the clinic had a mean age of 63.8 years; 700 (64.8%) were male, and 525 (48.6%) were Black or African-American. Breast cancer was the most common diagnosis, accounting for 423 (39.2%) of cancer diagnoses. Each patient travelled 4.8 (0.3–149.3) miles for a one-way trip and 9.6 (0.7–298.6) miles for a round trip to receive cancer care. Approximately 1,520 (280–119,440) g carbon were emitted per patient visit. A total of 79,582 round-trip miles was calculated for the 8,235 visits made by all patients within 1 year, which corresponds to 31,832 kg CO_2 emissions equivalent to 35,658 pounds of coal burned, 1,462 propane cylinders used for a home, or 3,872,250 smartphones charged.

Conclusion: Travel to receive cancer care is associated with significant carbon emissions and poses a climate and public health risk. Efforts to decrease the overall carbon footprint of cancer treatment are needed to minimise the contributions of cancer treatment to climate change.

Background

Climate change has been described as one of the grand challenges of the 21st century. The global impact of climate change is increasingly evident through progressively hotter temperatures, rising heatwaves in summer, increased flooding, record wildfires, destructive storms, and changing patterns of infectious diseases.[1,2] Anthropogenic activities aimed at improving human efficiency and overall quality of life now act as the driving force for climate change.[3] These changes have significant consequences for health, safety and the planet's future. In addition, efforts to optimise health through improved healthcare service provision, innovation and research have inadvertently rendered the healthcare industry one of the highest contributors to greenhouse gas (GHG) emissions.[4,5] Globally, healthcare systems are responsible for 5% of GHG emissions.[6] The toll of the US healthcare sector on the climate is particularly heavy compared to the rest of the world. Although the USA currently emits 11% of the annual global GHG, 8–10% of its emissions are from the healthcare industry.[4]

The GHG protocol corporate standard categorises GHG emissions into three groups tagged 'scopes': scope one or direct emissions, scope two or indirect emissions (from electricity or other energy sources), and scope three emissions, encompassing all other forms of indirect emissions.[7,8] Indirect emissions are the most significant source of healthcare-associated GHG emissions, accounting for 50–75% of all healthcare emissions.[6] Carbon emissions from patients' vehicular commute to receive care belong in this category. Transportation is the USA's

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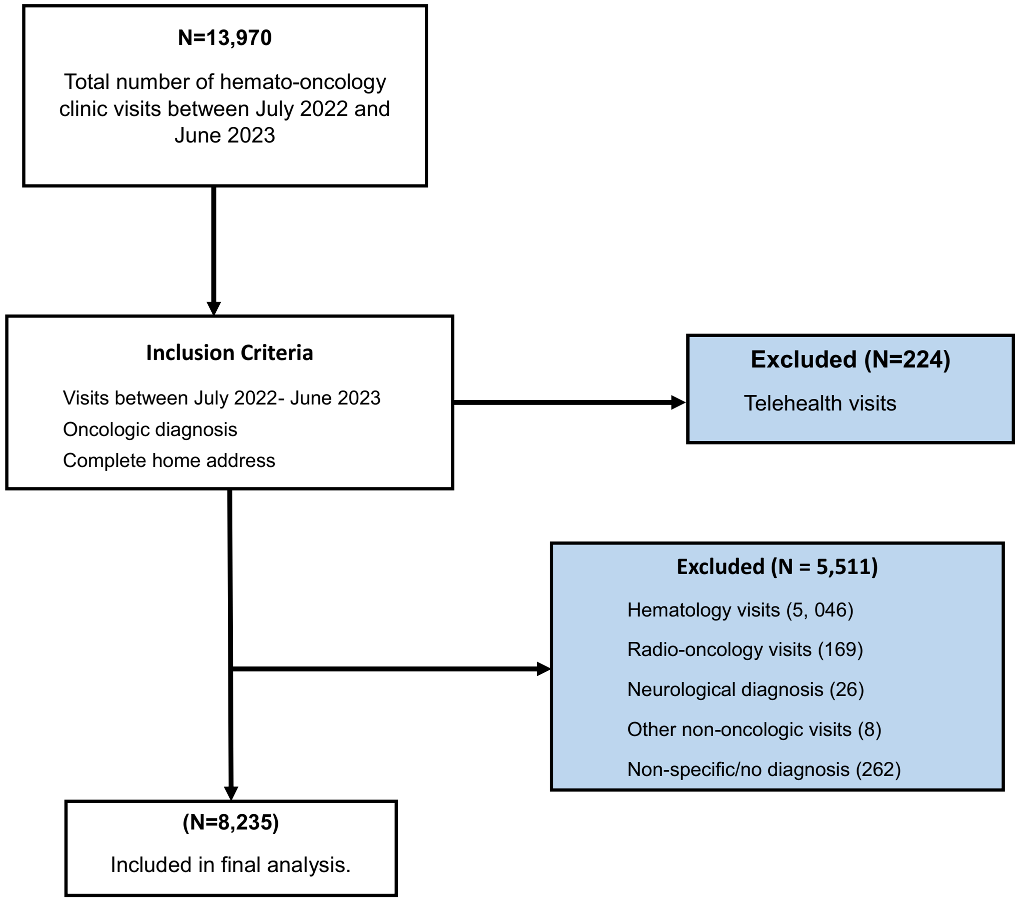

Fig. 1. study design.

highest source of GHG emissions, surpassing electricity generation.[9] Healthcare transportation, particularly the transportation of patients to access healthcare services, is a significant source of carbon emissions. In their study of 23,228 patients in 49,329 telemedicine visits necessitated by the COVID-19 pandemic,[10] Patel *et al* found that >6 million miles of travel time were saved, correlating to nearly 3 million kg in carbon emissions. The result of this study reiterates the significant contribution of patient travel to overall healthcare carbon emissions and the need for healthcare systems to rethink patient care in the context of their environmental impact. Depending on the stage at diagnosis, cancer treatment tends to be a long-term, sometimes lifelong process involving multiple treatments and, by extension, numerous hospital visits that easily span months to decades. Consequently, cancer care is associated with significant carbon footprints. Nonetheless, studies directly evaluating the contribution of patient transportation for cancer care to healthcare-associated carbon emissions remain limited. This study aims to estimate the carbon emissions of patient transportation among patients receiving care for oncologic malignancies at an urban community safety net hospital.

Methods

Participants and study design

The institutional review board (IRB) of the Albert Einstein College of Medicine granted an IRB exemption for this study. Therefore, the Human Ethics and Consent to Participate declaration is not applicable. We conducted a retrospective study of patients seen at the oncology clinic of an urban community safety net hospital in New York City between 1 July 2022, and 30 June 2023. Sociodemographic data (age, sex, race and ethnicity), visit diagnoses, and patient's home addresses were obtained from the hospital information system. Patients with at least one in-person visit within 1 year, documented home addresses, visit diagnoses and oncologic diagnoses were included in the study. Patients without visit diagnosis, haematologic visits, and telehealth visits were excluded from the analysis. Further information on study design and inclusion/exclusion criteria is presented in Fig. 1.

In addition to demographic data, detailed data on visit diagnosis, visit indication (eg laboratory visits, infusion visits, or follow-up), and patients' complete home addresses (house number, street name, city, state and Zipcode) were collected from the electronic medical records. The distance between each patient's home address and the hospital was calculated using the Google Map API key and a macro to calculate distance in metres. The distance travelled in metres was converted to miles. The estimated distance for a one-way patient trip was multiplied by two to determine the round-trip distance travelled in miles. To estimate carbon emissions from patients' travel, the distance travelled in miles was converted to CO_2 emissions using a conversion factor of 400 g CO_2 per mile based on the Environmental Protection Agency's (EPA's) estimate of the average carbon emissions for a passenger vehicle. The estimated carbon emissions were then converted to equivalents of coal burned, smartphones charged, and gallons of gasoline used based on the EPA equivalencies calculator.

The primary outcome was carbon emissions from patients' round-trip travel from home to hospital. This study did not require patient consent as no direct patient contact was required. The study followed the STROBE guidelines for data reporting.

Results

From 1 July 2022 to 30 June 2023, 13,970 visits were made to the oncology clinic of a community-based safety net hospital in New York

Table 1
Patient characteristics.

Characteristics	Patients (*n*=1,080)	Visits (*n*=8,235)
Mean age (years)	63.8	61.03
Sex, *N* (%)		
Male	700 (64.8)	5,424 (65.8)
Female	379 (35.1)	2,810 (34.1)
Other	1 (0.1)	1 (0.1)
Race, *N* (%)		
Black or African-American	525 (48.6)	4,327 (52.5)
White	139 (12.9)	943 (11.5)
Asian	40 (3.7)	396 (4.8)
Others	376 (34.8)	2,569 (31.2)
Diagnosis, *N* (%)		
Breast cancer	423 (39.2)	3,421 (41.5)
Prostate cancer	179 (16.6)	867 (10.5)
Colorectal cancer	106 (9.8)	942 (11.4)
Lung cancer	71 (6.6)	576 (7.0)
Endometrial cancer	59 (5.5)	471 (5.7)
Ovarian cancer	33 (3.0)	339 (4.1)
Others	209 (19.3)	1,619 (19.7)
Average distance per patient travel (range)		
Distance travelled (miles)	4.8 (0.3–149.3)	
Bi-directional distance travelled (miles)	9.6 (0.7–298.6)	

City. Of these, 8,235 visits made by 1,080 patients met the criteria for inclusion in the final analysis. Table 1. shows patient characteristics. Of the 8,235 visits recorded, 5,095 (61.8%) were follow-up/laboratory visits, and 3,137 (38.1%) were chemotherapy infusion visits. Each patient made an average of 7.6 (range, 1–91) visits in 1 year. The 1,080 patients who attended the clinic had a mean age of 63.8 years, 700 (64.8%) were male, 379 (35.1%) were female, 525 (48.6%) were Black or African-American, 139 (12.9%) were White, 40 (3.7%) were Asian and 376 (34.8%) were of other races. Breast cancer was the most common diagnosis, accounting for 423 (39.2%) of cancer diagnoses, 179 patients (16.6%) had prostate cancer, 106 (9.8%) had colorectal cancer, 71 (6.6%) had lung cancer, 59 (5.5%) had endometrial cancer, 33 (3.0%) had ovarian cancer, and 209 (19.3%) had other oncologic malignancies.

The distance travelled from patients' homes to the hospital was estimated for each patient and each visit. Each patient travelled 4.8 (0.3–149.3) miles for a one-way trip and 9.6 (0.7–298.6) miles for a round trip to receive cancer care. Approximately 1,520 (280–119,440) g carbon are emitted per patient visit. A total of 79,582 round-trip miles was calculated for the 8,235 visits made by all patients within 1 year, which corresponds to 31,832 kg CO_2 emissions, equivalent to 35,658 pounds of coal burned, 1,462 propane cylinders used for a home, or 3,872,250 smartphones charged.

Discussion

In this retrospective study of 1,080 patients who attended the oncology clinic of an urban community-based safety net healthcare centre, we found that patients travelled an average of 9.6 round-trip miles to seek medical care, corresponding to 1,520 g carbon emission per visit. A total of 79,582 round-trip miles were made in 8,235 visits, resulting in 31,832 kg CO_2 emissions, equivalent to 35,658 pounds of coal burned, 1,462 propane cylinders used for a home, and 3,872,250 smartphones charged.

To our knowledge, this is the first study to estimate the carbon emission of patients' travel to receive cancer care. Patient travel is a significant source of healthcare-associated carbon emissions.[6] In the study conducted by Patel *et al* to determine the carbon emissions saved by switching from in-person to tele-visits for cancer patients, an average of 10,32,775 round-trip miles (equivalent to 4,24,471 kg CO_2 emissions) were saved in 1 year, corresponding to 48.1 miles (19.8 kg CO_2 emissions) per visit for patients with a travel time of <60 min, and 66,77,002 round-trip miles (equivalent to 27,44,248 kg CO_2 emissions) corresponding to 239.8 miles (98.6 kg CO_2 emissions) per visit for patients who travelled >60 min.[10] These estimates are five times higher than reported in our study and can be attributed to differences between the institutions where the studies were conducted. The study by Patel *et al* was conducted at the Moffitt Cancer Center, a major cancer referral centre in the USA.[10] Hence, many patients from within and outside the state seek care at the centre and, therefore, travel long distances to access care. In contrast, our study was conducted within the oncology clinic of a community-based safety net healthcare system that caters primarily to patients who reside within 2–4 miles of driving distance from the facility and have poor resource availability. Nonetheless, the comparatively lower CO_2 emissions reported here remain relevant when considered in light of the current impact of climate change on the environment and the need to curtail carbon emissions and calls for the adoption of carbon-saving alternatives in healthcare delivery, such as a shift to telehealth visits.

For many cancer care centres, telemedicine is in its nascent stage, and even where it is well established, it is unlikely to fully replace in-person visits as many aspects of cancer care, such as imaging and complete physical exams, cannot be performed virtually. Hence, a balance between in-person and virtual visits is the goal. Other alternative care delivery methods, such as reducing laboratory visits through test drop-off services, can potentially reduce carbon emissions while maintaining optimal cancer care. In another retrospective study conducted over a 5-year period by an outpatient cancer centre, a rise in telehealth visits and a reduction in in-person healthcare visits corresponded to a decrease in carbon emissions from 8 to 4 kg CO_2 equivalents per visit. In addition to reducing healthcare-related carbon emissions, telehealth visits can reduce diagnostic and treatment delays, increase healthcare access for patients who live farther away from healthcare facilities, and potentially result in cost and time savings. Despite the demonstrated benefits of telemedicine, only 224 of the 13,700 total visits in our study were telehealth visits. One plausible explanation is that the institution of study caters to a low socioeconomic and educational population, which may directly or indirectly limit the adoption of telemedicine.[11,12] Patient education on telehealth utilisation, providing telemedicine support services, and staff training on telehealth services and policies can potentially reverse the trend and improve the adoption of telemedicine.[13]

In light of the UK's National Health Service's (NHS's) goals of cutting its CO_2 emissions by 80% below 1990 levels by 2050, a study was conducted to evaluate the reasons for high carbon emissions associated with outpatient surgery visits in the UK.[14] Findings from the study showed that patient travel accounts for 17% of the NHS's total carbon footprint. The study also found that most CO_2 emissions result from devising treatment plans without considering their environmental impact. Under the supervision of the Department of Health and Human Services (DHHS), a similar program in the USA helps track healthcare-related GHG emissions with the goal of reducing them eventually.[15] However, these efforts have been unsuccessful as data collected from 2010 to 2018 report a 6% rise in GHG emissions, with approximately four-fifths of the GHG emissions from the healthcare sector, highlighting the challenges posed by healthcare-associated emissions and efforts to address them.

Transportation remains the greatest source of carbon emissions for patients receiving cancer care. However, carbon emissions from other components of cancer care have been reported by some studies.[16,17] For example, Piffoux *et al* compared the carbon footprint and disability-adjusted life years (DALY) of standard immunotherapy-based regimens and other treatment strategies for patients with mantle cell lymphoma.[17] In this study, drug production, purchasing, general administrative costs and longer treatment duration were associated with increased carbon footprint. A focus on comprehensive studies that holistically estimate all aspects of cancer-associated carbon emissions will be crucial to promoting environment-friendly cancer treatment strategies and policy formulations.

While curtailing carbon emissions from patient transport can positively reduce emissions from cancer care, other mechanisms, including alternative treatment dosing, have been considered. In a modelling study on the scheduling of trastuzumab chemotherapy dosing for human epidermal growth factor receptor 2 (HER2)-positive breast cancer, alternative strategies to reduce GHG emissions, including a reduction in treatment frequency and overall duration of therapy, were explored.[18] The study evaluated three alternative dosing strategies of trastuzumab (6-month adjuvant treatment duration, once every 4-week dosing, and both) compared to commonly used dosing (12-month duration of adjuvant therapy and once every 3-week dosing). Adoption of both 6-month adjuvant trastuzumab and once every 4-week trastuzumab dosing was projected to reduce GHG emissions by 4.5%, 18.7% and 14.6% in the neoadjuvant, adjuvant and metastatic groups, respectively. Thus, alternative dosing schedules could help reduce overall cancer care-related carbon footprint and be used synergistically with other environment-friendly strategies like the shift to telemedicine where feasible, which is expected to significantly reduce carbon emissions associated with cancer care. However, there are currently no clinical trials on alternative dosing strategies and their impact on overall treatment outcomes and implications for greenhouse gas emissions. Future studies focused on highlighting the benefits of alternative dosing strategies are needed. The use of oral agents, where appropriate, could also potentially reduce the need for treatment visits, thereby reducing travel-associated emissions.

Limitations

Carbon emission was calculated using EPA's estimates for passenger vehicles to simplify the calculation of average carbon emissions from patients' travel. We however acknowledge that other forms of transportation, including public transportation services, may have been utilised by patients, and our current estimates may be higher than expected as a result.

Conclusions

In conclusion, travel to receive cancer care is associated with significant carbon emissions and poses a climate and public health risk. Efforts to decrease the overall carbon footprint of cancer treatment, such as the adoption of telemedicine, improving technological access of patients, and alternative treatment schedules, are needed to minimise the contributions of cancer treatment to climate change.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Hasiya Yusuf: Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **Rajvi Gor:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis. **Charan Vegiventi:** Writing – review & editing, Writing – original draft. **Abhishek Kumar:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization.

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