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Carbon Footprint Reduction Associated With Multidisciplinary Pediatric Airway Clinics: A Program Evaluation Study

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Abstract

Objective. Health care is a significant contributor to the climate crisis. Multidisciplinary clinics (MDC) may reduce carbon emissions by combining multiple appointments into one. This is the first program evaluation study to quantify the carbon footprint associated with multidisciplinary pediatric airway clinics.

Study Design. Retrospective.

Setting. Children's Hospital at London Health Sciences Center, London, Canada.

Methods. Pediatric airway MDC allows patients to see otolaryngology and respirology in one appointment. The carbon and financial savings (Canadian Dollars) of all patients attending the MDC from January 1, 2018 to December 31, 2022 were calculated. Patient postal codes and institutional parking rates were inputted into the CASCADES carbon accounting tool. Total distance was divided into unsustainable (vehicles) and sustainable (transit, walking, cycling) transportation to calculate carbon emissions. Travel costs included cost/kilometer for vehicles (maintenance, license/registration, insurance, fuel) and costs/ride for transit.

Results. A total of 560 MDC appointments for 300 patients saved 77,785 km. Total carbon emissions saved from travel averted was 16.21 tonnes. The total carbon emissions saved, minus public transit, was 15.60 tonnes. Using the Natural Resources Canada Greenhouse Gas Equivalencies Calculator, 16.21 tonnes are approximately equivalent to 5 passenger vehicles, 6906 L of gasoline, 3.8 homes' energy, and 10.8 homes' electricity use for one year, 36.6 barrels of oil consumed, and 675 propane cylinders. Travel costs of $28,891.83 (no parking), $30,519.40 ($4 minimum parking fee), or $33,774.55 ($12 maximum parking fee) were saved.

Conclusion. MDC effectively reduced carbon emissions and offered patients financial savings. Similar models can be adapted across institutions to help mitigate climate change.

Keywords

carbon savings, climate change, environmental sustainability, otolaryngology

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Climate change is the most significant global threat to environmental and human health.[1-3] Our planet's temperature continues to rise and is expected to increase by up to 5°C by 2050.[4] Health care is a significant contributor to the climate crisis as an estimated 4.5% of Canada's and 8.5% of the United States' total greenhouse gases (GHGs) are from the health care sector.[5-7] Novel clinic formats, including surgical outreach and virtual clinics, have been shown to reduce carbon emissions through a reduction in patient travel to appointments.[8-13]

Multidisciplinary clinics (MDC) have been developed in various specialties.[14-23] These clinics provide collaborative care from multiple medical specialties and health professionals for patients with complex diseases. Care for these patients has classically been provided in silos.[19] Otolaryngology–Head and Neck Surgery (OHNS) has implemented effective MDCs for dizziness, head and neck

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cancer, and airway diseases.[17-23] These MDCs have improved diagnostic accuracies and patient satisfaction while reducing costs, treatment delays, and the number of appointments patients attend.[15,17,18,23]

The need for MDCs is emphasized among pediatric patients with complex airway and aerodigestive disorders as they often require a broad spectrum of care involving many health care teams. Coordinating appointments is challenging when balancing health resource availability with parent and child schedules. Further, these patients often undergo procedures performed in collaboration with OHNS and respirology.[24] If provided individually, this requires 2 separate appointments which can result in diagnostic delays.[24]

Ruiz et al outline the effective implementation of a pediatric MDC program at the Children's Hospital in Colorado.[23] This program effectively reduced costs and procedure/anesthesia times while ensuring patient and family satisfaction.[23] Although studies have suggested that MDCs reduce the number of appointments for patients, no study has quantified the carbon footprint reduction associated with MDCs through the reduction of patient travel to appointments.[15]

This program evaluation study assessed both the carbon emission and financial savings associated with pediatric airway MDCs at the Children's Hospital at London Health Sciences Center (CH-LHSC), in London, Ontario, Canada, using the CASCADES virtual carbon accounting tool.[25] To the authors' knowledge, this is the first study to quantify the carbon footprint associated with MDCs.

Methods

Study Design and Participants

This study received an ethics exemption from the Research Ethics Board at Western University (London). The reporting of this study is consistent with SQUIRE guidelines. The divisions of Pediatric OHNS and Pediatric Respirology at the CH-LHSC have developed collaborative MDCs where patients see both the pediatric otolaryngologist and respirologist in 1 appointment. The study comprised all pediatric patients (<18 years old) who attended a pediatric airway MDC at the CH-LHSC from January 1, 2018 to December 31, 2022. Decision Support provided the postal codes of patients who had an appointment at this MDC during the study period. Patients who did not have a postal code, had missing appointment data, or did not attend an MDC airway clinic appointment were excluded. No other patient data was collected.

Data Analysis

We used the CASCADES virtual carbon accounting tool to assess the carbon (metric tonnes of CO_2) and financial savings in Canadian Dollars (CAD) associated with MDCs at CH-LHSC during the inclusion period of the study. The CASCADES tool is a publicly available Excel sheet with preset calculation parameters.[25] This tool was created to help account for financial and carbon savings due to virtual health care appointments.[25]

Due to the pediatric airway MDC involving 2 specialty teams: otolaryngology and respirology, each appointment at this MDC saves the patient 1 trip to the hospital. The postal codes of the patient and CH-LHSC, along with the price of parking at CH-LHSC, were inputted into the CASCADES tool for data analysis. The postal code of the CH-LHSC used in this study was N6A 5W9.[26] The total transportation distance averted in kilometers (km), total metric tonnes of CO_2, and financial (CAD) savings during the study period were reported. Total transportation distance was divided into unsustainable (vehicles) and sustainable (transit, walking, cycling) transportation to calculate carbon emissions. Travel costs included cost/km for vehicles (maintenance, license/registration, insurance, and fuel) and costs/ride for transit. Data from the Government of Canada was referenced in the CASCADES virtual carbon accounting tool to appropriately account users by percentage of type of transportation users, type of vehicles driven, and the average emission factor (g/km) in the specific jurisdiction of London.[25] The data for the proportion of commuters using unsustainable and sustainable transportation was specific to our jurisdiction of London. The data was based on the Canada Census 2016 results for Mode of Transport by Census Metropolitan Area.[25] An average emissions factor (EF) of 260 g/km of CO_2 was used. This average EF was for the 10 most popular cars purchased in Canada in 2021. The minimum cost of parking at the LHSC for 1 hour is $4 and the daily maximum parking fee is $12.[25,27] Both parking fees were calculated.

Among the MDC appointments that were included in the study, a subanalysis was completed to address potential Covid-19 pandemic appointment bias. An independent sample *t* test was used to compare the monthly average number of multidisciplinary team (MDT) appointments prepandemic (March 2019 to February 2020) to the monthly average number of MDT appointments during the pandemic (March 2020 to February 2021) to account for seasonality effects.

Results

Of 652 otolaryngology and respirology appointment visits recorded at CH-LHSC, 560 appointments were identified as collaborative MDC visits and met the inclusion criteria (**Figure 1**). These MDC appointments corresponded to 300 pediatric patients. The 560 MDC appointments between January 2018 and December 2022 saved a total of 77,785 km for roundtrips. **Figures 2** and **3A** and **B** display the postal codes of patients and of CH-LHSC for orientation of distance traveled for patients to their MDC appointment. **Table 1** provides the distance saved (km) by transportation type, including vehicle, public transit,

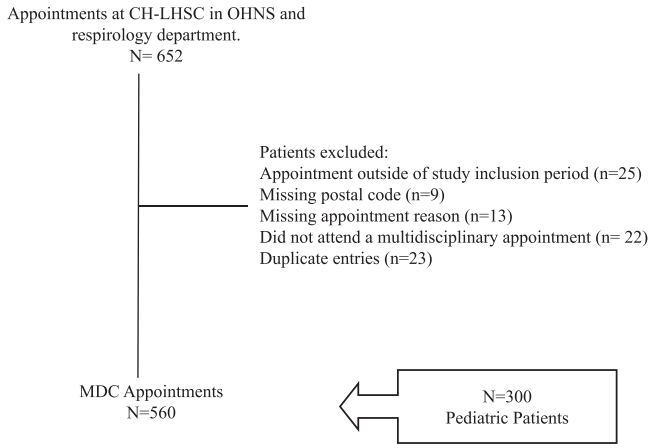

Figure 1. Multidisciplinary clinic appointments inclusion flowchart. CH-LHSC, Children's Hospital at London Health Sciences Center; MDC, multidisciplinary clinics; OHNS, Otolaryngology–Head and Neck Surgery.

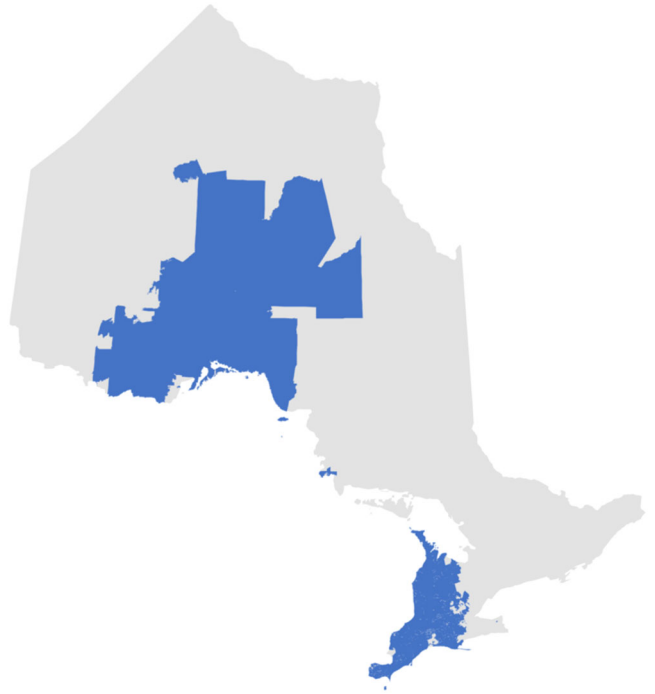

Figure 2. Excel map feature highlighting postal code regions of patients and institutions.

carpooling, walking, and cycling. **Table 2** provides the percentage of each type of transportation user as per the CASCADES virtual carbon accounting tool.[25] The total carbon emissions saved from travel averted was calculated to be 16.21 tonnes of CO_2. The total carbon emissions saved, minus public transit, was 15.60 tonnes of CO_2. Using the Natural Resources Canada Greenhouse Gas Equivalencies Calculator, 16.21 tonnes are approximately equivalent to 5 passenger vehicles, 6906 L of gasoline, 3.8 homes' energy and 10.8 homes' electricity use for 1 year, 36.6 barrels of oil consumed, and 675 propane cylinders.[28] Travel costs of $28,891.83 CAD (no parking), $30,519.40 CAD ($4 minimum parking fee), or $33,774.55 CAD ($12 daily maximum parking fee) was saved. The average cost per patient was $95.03 CAD (no parking), $100.39 CAD ($4 minimum parking fee), or $111.10 CAD ($12 daily maximum parking fee).

In our subanalysis, we found a significant decrease of an average of 2.42 monthly appointments observed during the 12-month peripandemic period (March 2020 to February 2021, monthly mean [SD]: 7.08 appointments [2.35]) compared to the 12-month prepandemic period (March 2019 to February 2020: monthly mean [SD]: 9.50 appointments [3.92]), t (22) = 1.82, P = .042 (95% confidence interval: 0.36-5.19) (**Figure 4**). The average monthly difference of 2.42 clinic appointments is equivalent to approximately 29 appointments per year. Thus, there is a potential for an approximately 5% increase in carbon emission savings over the 5-year term.

Discussion

This program evaluation study shows that MDC appointments have the potential to significantly impact the climate emergency in health care by reducing carbon emissions as well as leading to financial savings for patients. Recently, there has been an increased aim to build sustainable health care services to establish a net-zero health care system by 2050.[29-31] A net-zero health care system signifies cutting carbon output to as close to zero to prevent catastrophic impacts of climate change and preserve a livable planet.[32] To reach net-zero health care, it will require several robust transformational actions beyond expanding virtual health care, such as implementing climate resilient infrastructure, focusing on alleviating stress on hospitals by focusing on chronic disease management, disease prevention, and health promotion, shifting to renewable energy sources, and practicing sustainable prescribing and use of medical supplies.[31,33]

Currently, to our knowledge, there have been no studies in the literature to quantify the carbon footprint associated with MDCs. We have identified that reducing patient travel to institutions through MDC appointments can lead to both carbon emissions and financial savings using the CASCADES virtual care carbon accounting tool. CASCADES, an initiative funded by Environment and Climate Change Canada, continues to work with health care communities to transition health care into a high-quality, low-carbon, sustainable, and climate-resilient system.[25] In our study, over 16 tonnes of carbon emissions were saved with 560 MDC appointments. The carbon emissions savings findings presented in our study is only a small part of a solution to reducing the carbon footprint in health care. However, the MDC initiative holds the potential in playing a major role to significantly reducing health care's carbon footprint if institutions across North America begin to adopt these types of clinics.

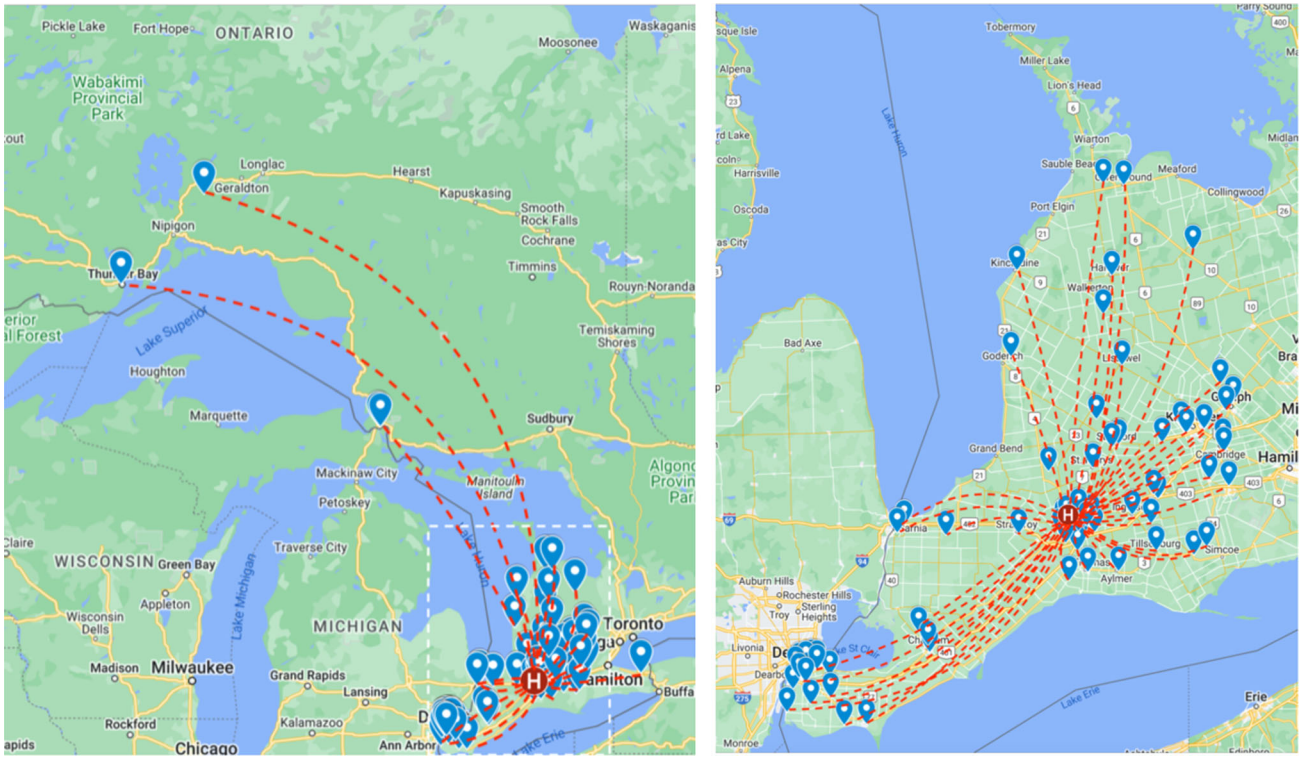

Figure 3. Map highlighting patient postal codes attending the multidisciplinary clinic at the Children's Hospital at London Health Sciences Centre (red H). The Left is zoomed out of Ontario patients. Right is the outline of Southwestern Ontario patients.

Table 1. Savings for Second Appointments, Travel Distance, and Carbon Emissions

Savings	Appointments	Value
	Second appointment visit	560
km		
	km for a round-trip with a private vehicle	56,517.89
	km for round-trip with public transit	5636.08
	km for a round-trip with carpooling	10,439.58
	km for a round-trip with walking	4314.77
	km for a round-trip with cycling	876.23
	Total distance (km) saved	77,785
GHG emissions, g		
	Emissions saved using a private vehicle	14,694,650.75
	Emissions saved using public transit	612,750.56
	Emissions saved using carpooling	904,763.29
	Emissions saved using walking	0
	Emissions saved using cycling	0
	Total emissions saved	16,212,164.6
Financial savings, CAD		
	Travel costs saved without parking	28,891.83
	Travel costs saved with minimum parking fee	30,519.40
	Travel costs saved with maximum parking fee	33,774.55

Abbreviations: CAD, Canadian dollars; GHG, greenhouse gas; km, kilometers.

Table 2. Percentage of Type of Transportation Users

Type of transportation users	Percentage, %
Total transportation users	100
Sustainable transportation users	27.3
Unsustainable transportation users	72.7
Public transport users	7.2
Carpooling users	13.4
Commuters who walk	5.5
Commuters who cycle	1.1

Although studies have focused on how telemedicine care decreases GHGs within the health care system, there are various clinic visits that are not amenable to virtual care.[10] For example, otolaryngology virtual care has several limitations as these visits rely heavily on physical examination, including endoscopy, to evaluate the upper airway and aid in diagnosis.[34] To support the transition to a net-zero health care system when virtual care is not feasible, our study proposes the use of MDCs. While we recognize that there are multiple contributors to the carbon footprint from a facility itself including the electricity and heat, our study focused on the carbon footprint reduction from patient travel. Although MDC appointments may be argued to take a longer duration than a single appointment, we did not input this as an

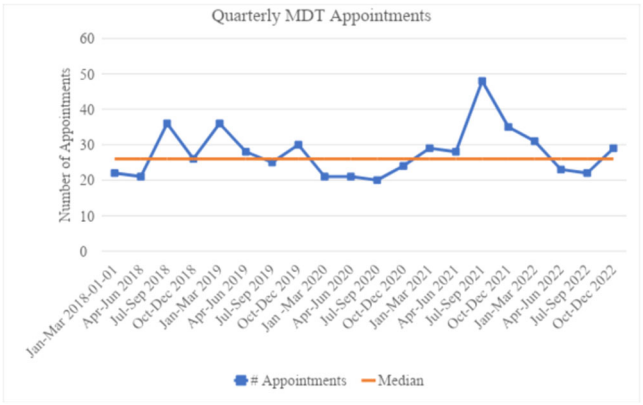

Figure 4. Quarterly appointments during peripandemic period (March 2020 to February 2021) and prepandemic period (March 2019 to February 2020). MDT, multidisciplinary team.

additional carbon footprint contributor as the hospital facility would have used the allocated carbon emissions for the second patient appointment regardless. This indicates that while there may not be significant carbon footprint reductions in the facility with MDCs, it would not increase the footprint due to a longer appointment either. MDCs allow patients to be seen by different specialists on the same day which overall minimizes travel carbon emissions to the hospital clinic.[33] Furthermore, these clinics benefit patients as it offers improved coordination of care, less time away from school or work, and reduces travel costs.[23] The opportunity to minimize travel to an institution for patients using MDCs is especially highlighted in our study. Some patients visiting CH-LHSC in London come from very far distances that most likely include air travel, such as Thunder Bay. This reduction in appointment travel leads to a significant decrease in both carbon emissions and financial savings for these far-distance patients. Furthermore, MDCs for patients that require an interpreter due to language barriers would also save on the interpreter travel and cost as well. While there are many advantages to implementing and developing MDCs for patient care, there are also several potential barriers.[35] MDCs implementation in institutions have faced many barriers at a system, physician, and patient levels. Some of these barriers include high and comprehensive administrative work, lack of synchronism between different providers at different institutions, inadequate infrastructure to execute an MDC at all institutions, excessive caseload for physicians, and lack of teamwork and leadership to participate in MDC.[35] These barriers that hinder MDC development would require the active involvement of all stakeholders, including government, institutional, health care providers, and patients, to overcome and implement these high-quality MDCs. The efforts toward effective implementation of MDCs will not only improve patient care, but also contribute toward a net-zero health care system.

Our study has several strengths. Using hospital administrative data, we had access to demographic information for a large cohort of pediatric patients attending MDCs at CH-LHSC. We avoided biases associated with self-reported data. Furthermore, this was the first study, to our knowledge, to quantify the carbon footprint associated with MDCs in the published literature. Another noteworthy strength of our study is the potential to generalize or replicate similar MDCs in different institutions across Canada. The potential for replication in various locations could lead to notable decreases in carbon emissions. Our study has several limitations. While we used patient data to capture postal codes and confirm that patients attended MDC airway clinic appointments, we did not complete a comprehensive chart review of all 300 unique patients. However, for quality assurance purposes, we conducted an audit of 10% of patient electronic health records to confirm study inclusion/exclusion criteria; and found that 4.7% of patient entries should have been excluded. Thus, there may be a small number (<5%) that may represent an overestimate. Another limitation was using an estimated prediction of patients who use unsustainable (vehicles) and sustainable (transit, walking, cycling) transportation. For this study, the transportation data that the CASCADES virtual accounting tool used in the data analysis was derived from a Statistics Canada Census.[25,36] As per the Statistics Canada Census, it shows the prevalence of sustainable transportation in large cities in comparison to mid-size cities such as London. For example, Toronto, Vancouver, and Montreal have 42.5%, 40.6%, and 38.1%, respectively, of the population using sustainable transportation in comparison to 27.3% in London.[36] This highlights the limited sustainable transport in the area of our study. Future studies could collect the means of travel from each patient using questionnaires to provide more accurate carbon emissions and financial savings data. This would also account for whether patients traveled to the institution by plane or train from further destinations. While a plane would emit more carbon emissions, the use of MDCs reduced the need to travel by air by 50%. Next, the Covid-19 pandemic may attribute a limitation for accurate carbon emission savings during the study period. The pandemic presented numerous challenges for the health care system. The pandemic caused significant modifications to outpatient clinic services with the introduction of otolaryngology telephone consultations, rescheduling, or delays of medical appointments.[29] Our study found a significant monthly decrease of approximately 2.5 appointments peripandemic. Therefore, there is potential for underestimation of travel and cost savings due to the COVID-19 pandemic.

Implications for Clinical Practice

In conclusion, this study highlights that MDCs effectively reduce carbon emissions and offer patients financial savings. The results provide valuable insights into how similar multidisciplinary models can be adapted across health care institutions to help mitigate climate change and ultimately improve environmental sustainability.

Author Contributions

Alina Zgardau, data analysis, interpreting data, writing manuscript; **Kalpesh Hathi**, study design, interpreting data, writing manuscript; **James Fowler**, study design, interpreting data, revising manuscript, supervision; **Tara Mullowney**, study design, interpreting data, revising manuscript; **April Price**, study design, interpreting data, revising manuscript; **Murad Husein**, study design, interpreting data, revising manuscript; **M. Elise Graham**, study design, interpreting data, revising manuscript; **Agnieszka Dzioba**, study design, data analysis planning, interpreting data, submitting REB exemption application, revising manuscript; **Edward Madou**, study design, interpreting data, revising manuscript; **Julie E. Strychowsky**, study initiation and conceptualization, study design, interpreting data, revising manuscript, supervision.

Disclosures

Competing interests: The authors declare no conflicts of interest upcoming or existing in the previous 24 months that pertain to this article.

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