Canadian Medical Education Journal
Revue canadienne de l'éducation médicale

A chance for reform: The environmental impact of travel for general surgery residency interviews
Une occasion d'introduire une réforme : l'impact environnemental des déplacements faits pour se rendre à une entrevue de stage en chirurgie générale

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Volume 12, Number 3, 2021

URI: https://id.erudit.org/iderudit/1080220ar
DOI: https://doi.org/10.36834/cmej.71022

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Publisher(s)

Canadian Medical Education Journal

ISSN

1923-1202 (digital)

Explore this journal

Cite this article

Fung, B., Raiche, I., Lamb, T., Gawad, N., MacNeill, A. & Moloo, H. (2021). A chance for reform: The environmental impact of travel for general surgery residency interviews. *Canadian Medical Education Journal / Revue canadienne de l'éducation médicale*, *12*(3), 8–18. https://doi.org/10.36834/cmej.71022

Article abstract

Background: In light of the global climate emergency, it is worth reconsidering the current practice of medical students traveling to interview for residency positions. We sought to estimate carbon dioxide (CO2) emissions associated with travel for general surgery residency interviews in Canada, and the potential avoided emissions if interviews were restructured.

Methods: An 8-item survey was constructed to collect data on cities visited, travel modalities, and costs incurred. Applicants to the University of Ottawa General Surgery Program during the 2019/20 Canadian Resident Matching Service (CaRMS) cycle were invited to complete the survey. Potential reductions in CO2 emissions were modeled using a regionalized interview process with either one or two cities.

Results: Of a total of 56 applicants, 39 (70%) completed the survey. Applicants on average visited 10 cities with a mean total cost of $4,866 (95% CI=3,995-5,737) per applicant. Mean CO2 emissions were 1.82 (95% CI=1.50-2.14) tonnes per applicant, and the total CO2 emissions by applicants was estimated to be 101.9 (95% CI=84.0 – 119.8) tonnes. In models wherein interviews are regionalized to one or two cities, emissions would be 57.9 tonnes (43.2% reduction) and 84.2 tonnes (17.4% reduction), respectively. Overall, 74.4% of respondents were concerned about the environmental impact of travel and 46% would prefer to interview by videoconference.

Conclusion: Travel for general surgery residency interviews in Canada is associated with a considerable environmental impact. These findings are likely generalizable to other residency programs. Given the global climate crisis, the CaRMS application process must consider alternative structures.

Canadian Medical Education Journal **Major Contributions**

A chance for reform: The environmental impact of travel for general surgery residency interviews

Une occasion d'introduire une réforme : l'impact environnemental des déplacements faits pour se rendre à une entrevue de stage en chirurgie générale

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Published ahead of issue: January 20, 2021; Published: June 30, 2021. CMEJ 2021, 12(3). Available at http://www.cmej.ca

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Abstract

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Methods: An eight-item survey was constructed to collect data on cities visited, travel modalities, and costs incurred. Applicants to the University of Ottawa General Surgery Program during the 2019/20 Canadian Resident Matching Service (CaRMS) cycle were invited to complete the survey. Potential reductions in CO_2 emissions were modeled using a regionalized interview process with either one or two cities.

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Conclusion: Travel for general surgery residency interviews in Canada is associated with a considerable environmental impact. These findings are likely generalizable to other residency programs. Given the global climate crisis, the CaRMS application process must consider alternative structures.

Résumé

Contexte: Compte tenu de la situation d'urgence climatique mondiale, il convient de reconsidérer l'usage actuel selon lequel les étudiants en médecine se déplacent pour se présenter aux entrevues en vue d'obtenir un poste de résidence. Nous avons tenté d'estimer les émissions de dioxyde de carbone (CO_2) causées par les déplacements pour les entretiens de résidence en chirurgie générale au Canada, et les émissions potentielles évitées si les entretiens étaient organisés autrement.

Méthodes : Un sondage comportant huit questions a été élaboré pour recueillir les données sur les villes visitées, les modalités de voyage et les coûts encourus. Les candidats au programme de chirurgie générale de l'Université d'Ottawa au cours du cycle 2019/20 du Service canadien de jumelage des résidents (CaRMS) ont été invités à y répondre. Les réductions potentielles des émissions de CO_2 ont été modélisées à l'aide d'un processus d'entrevue régionalisé avec une ou deux villes.

Résultats : Sur un total de 56 candidats, 39 (70 %) ont répondu au sondage. Les candidats ont visité en moyenne 10 villes, pour un coût total moyen de 4 866 dollars (IC 95 % = 3 995-5 737) par candidat. Les émissions moyennes de CO_2 étaient de 1,82 (IC 95 % = 1,50-2,14) tonne par candidat, et le total des émissions de CO_2 pour l'ensemble des candidats était estimé à 101,9 (IC 95 % = 84,0 - 119,8) tonnes. D'après les modèles où les entrevues sont régionalisées avec une ou deux villes, les émissions seraient respectivement de 57,9 tonnes (43,2 % de réduction) et 84,2 tonnes (17,4 % de réduction). Dans l'ensemble, 74,4 % des personnes interrogées se disent préoccupées par l'impact environnemental des déplacements et 46 % préféreraient que l'entretien se fasse par vidéoconférence.

Conclusion : Les déplacements pour les entrevues de résidence en chirurgie générale au Canada ont un impact environnemental considérable. Ces conclusions sont probablement généralisables à d'autres programmes de résidence. Compte tenu de la crise climatique mondiale, il conviendrait d'envisager d'autres modalités d'organisation des entrevues pour le processus de candidatures du CaRMS

Introduction

Climate change is one of the greatest threats to human health and health systems in our generation.[1] Diseases caused by pollution are responsible for approximately 16% of all deaths worldwide each year, which is more than deaths from smoking, AIDS, tuberculosis, and malaria combined.[2] Given these public health implications, healthcare professionals have a duty to advocate for climate action and to reflect on how our systems and behaviours contribute to this issue.[3]

One process that most physicians in Canada and the United States participate in is the residency application process. Each year, thousands of graduating Canadian medical students participate in the Canadian Residency Matching Services (CaRMS) and travel to cities across the country to interview for residency programs. Candidates attend an average of greater than seven interviews per cycle and, with little scheduling coordination between programs, this typically entails a considerable number of flights, sometimes crossing the country several times.[4] This flight frequency is particularly concerning given that a single round trip flight spanning the distance of the continental United States (U.S.) produces mores CO_2 than the average annual emissions of a person living in many countries around the world.[5,6] While many studies have advocated for reform to the interview process both in Canada and the U.S.[7-11] citing the significant financial burden for applicants,[12-16] there is little mention in the literature of the environmental impacts. Suggested alternatives include regionalizing interviews such that candidates and program delegates travel to a limited number of cities to conduct interviews—urology programs in Canada have held a one-day interview fair in Toronto, Canada since 1994, demonstrating the feasibility of this approach.[17] An alternative which will soon be tested is videoconferencing as all residency interviews in Canada for the 2020/21 application cycle will be conducted with this technology in response to the COVID-19 pandemic.[18] The Association of American Medical Colleges (AAMC) have made similar recommendations for the 2020/2021 residency application cycle in the United States.[19] Understanding the environmental impact of the current CaRMS interview model and exploring alternatives to reduce CO_2 emissions is in keeping with our imperative to preserve and promote planetary health. Research into alternate solutions to in-person interviews is especially relevant in the context of the COVID-19 pandemic.

The purpose of this study was to quantify CO_2 emissions associated with travel during the CaRMS process for general surgery applicants interviewing at a single academic institution in Canada. Secondary objectives included estimating the avoided CO_2 emissions of alternative interview structures and assessing applicants' attitudes towards the current interview process.

Methods

Questionnaire design and dissemination

This study adhered to the Checklist for Reporting Results of Internet E-Surveys (CHERRIES).[20] We created an 8-item survey that asked applicants which cities they visited during their interviews, modes of travel, estimation of costs incurred, and their sentiments with respect to the interview process (Appendix A). The survey was designed by a multidisciplinary panel with expertise in survey design, clinical epidemiology, medical education, and climate change. Questions were kept in a fixed order on a single page, were non-adaptive, and were a combination of free-response, multiple choice, and Likert scale formats. The survey was piloted with general surgery resident physicians and revised for brevity and ease of completion prior to dissemination.

This was a voluntary closed survey hosted on the SurveyMonkey platform (SurveyMonkey Inc. San Mateo, California, USA) and distributed by email. The target population was a convenience sample of all medical students who were invited for an interview for the General Surgery Residency Program at the University of Ottawa for the 2019/2020 application cycle. As the majority of general surgery applicants apply and interview at most programs across Canada, this sample captures the majority of general surgery applicants in Canada.[4] Informed consent was detailed in the survey description. Unique site visitors were confirmed using an IP address check and log file analysis. Respondents were able to review responses prior to submission. Responses were collected in February 2020. Surveys with incomplete data were analyzed on a case-by-case basis and were excluded if more than two items were incomplete.

Cost, distance, and CO_2 emissions calculation

Respondents reported a cost range for each spending category (see Figure 2). We used the median value of each cost range to calculate each respondent's total costs. Distances travelled by car and bus were estimated using the shortest driving route suggested by Google Maps. Distances travelled by train were estimated using distance route maps published by the rail operator.[21] CO_2 emissions from travel by car (light-duty, gasoline), bus (heavy-duty, diesel), and train (diesel) were estimated using emissions data (metric tonnes of CO_2 per km) reported by Environment Canada.[22] CO_2 emissions from travel by flight were estimated using Flight Emissions Calculator from MyClimate.org, an international non-profit from the Swiss Federal Institute of Technology.[23] The methodology of this calculator is well described, and corrects for Great Circle Distance, aircraft type, average seat occupancy, and cabin class to calculate CO_2 equivalent emissions per individual passenger. To estimate the total CO_2 emissions of the entire general surgery applicant cohort, the average CO_2 emissions of the survey respondents was multiplied by the total number of interviewees at the University of Ottawa this year. Where there were multiple flight routes available, the route with the least number of stops was chosen. For international medical graduates (IMGs), only travel within Canada was included, whereas international flights were excluded. For analysis by region of origin, IMGs were classified to the region where they first interviewed at.

Regionalized interview modelling

To simulate the potential CO_2 emission reductions if interviews were regionalized, we constructed two models in which candidates flew to one (Toronto, ON) or two cities (Toronto and Calgary, AB) for their interviews, using city of origin data submitted in each applicant's CaRMS application. These cities were selected as they had the shortest average direct flight distance from major Canadian cities. To account for the emissions associated with programs sending delegates to conduct interviews, our models had each general surgery program send five delegates to these cities and factored in the CO_2 emissions associated with their flights. We chose this number based on the Canadian Urology interview fair—which uses the One-City model—and our colleagues estimate of the average number of delegates per program. In the One-City Model, all applicants and candidates flew to Toronto, then returned to their home cities. In the Two-City Model, programs west of Winnipeg, Manitoba (inclusive) sent delegates to Calgary, whereas programs east of Winnipeg, Manitoba sent delegates to Toronto. We assumed all applicants had interviews at both eastern and western region programs, and had all applicants fly from their home city to Toronto, then to Calgary, then back to their home city—the reversal flight path is equal in distance and emissions. We assumed all applicants took flights for inter-city travel unless they lived in the city in which the interviews were being held or if they were within a 1-hour driving distance (Hamilton, ON and Toronto, ON). CO_2 emissions calculated from these models were compared to the CO_2 emissions calculated from our survey data, which we called the Current Model.

Statistical analysis

A one-way ANOVA was used to compare costs and CO_2 emissions by region of origin. An independent-samples t-test was used to compare CO_2 emissions between the Current Model and the One-City Model, and the Current Model and the Two-City Model. Statistical analyses were performed using IBM SPSS Statistics (IBM Corp, Released 2019. IBM SPSS Statistics for Windows, Version 26.0. Armonk. NY: IBM Corp.)

Ethics approval: Our institutional review board granted a waiver for this study as it falls within the context of quality improvement and program evaluation.

Results

Of 56 general surgery applicants invited for an interview at the University of Ottawa, 39 responded to the survey (70% response rate). Aside from three respondents who did not indicate the cities in which they interviewed at and therefore were not included in the travel emission calculations, complete data was obtained from all respondents.

A breakdown of respondents' region of origin can be found in Figure 1. The regional distribution of respondents was similar to the regional distribution of all applicants, and the majority of respondents were from Ontario and Quebec. Overall, respondents interviewed at a mean of 10 cities (95% CI=8-12), with a mean estimated travel cost of $4866 (95% CI=3995-5737) which is approximately $629 per city (95%

CI=436-821; Table 1, Figure 2). If this mean travel cost was extrapolated to the entire 2019/2020 general surgery interview cohort (*n* = 56), the total estimated travel costs for the 2019/2020 applicant cohort was approximately $272,496 (95% CI=223,720-321,272) The majority of costs were related to intercity travel (58%), followed by accommodations (23%; Figure 3). Travel costs were not significantly different between respondents from different regions.

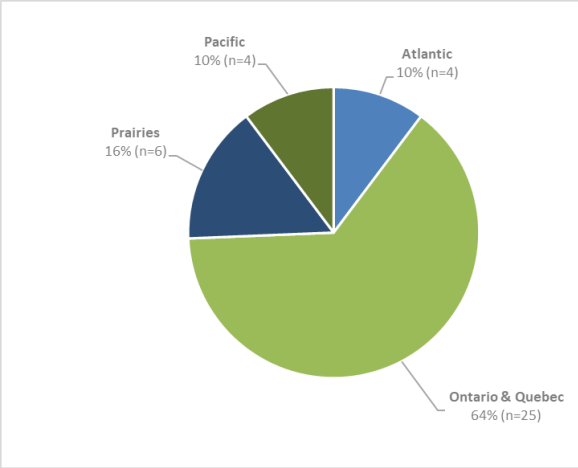


Figure 1. Respondent region origin

After aggregating CO_2 emissions from inter-city travel by all modes of transportation, mean CO_2 emissions per respondent were approximately 1.8 tonnes (95% CI=1.50-2.14), or approximately 0.2 tonnes per city (95% CI=0.16-0.20). If this mean CO_2 emission rate was extrapolated to the entire 2019/2020 interview cohort (*n* = 56), the total estimated CO_2 emission for this year's cohort was 101.2 tonnes (95% CI=84.00-119.84). The vast majority of CO_2 emissions were related to travel by flights (89%), followed by travel by car (8%). CO_2 emissions were not significantly different between respondents from different regions based on a one-way ANOVA.

Table 1. Summary of survey responses for applicant cost and emissions estimates.

General	
Respondents - (%)	39/56 (69.6%)
Avg. # of Cities Visited - (95%CI)	10 (8 - 12)
Costs - $CAD (95% CI)	
Avg. Travel Cost Per Respondent	4866 (3995 - 5737)
Avg. Travel Cost Per City	607 (415-799)
Total General Surgery Costs	272,496 (223,720 - 321,272)
Avg. Cost by Region	
Atlantic	6812 (4289 - 9336)
Ontario & Quebec	4451 (3338 - 5563)
Prairies	4938 (3083 - 6792)
Pacific	5406 (-1489 - 12300)
Emissions - tonnes (95% CI)	
Avg. Emissions Per Respondent	1.82 (1.50 - 2.14)
Avg. Emissions Per City	0.18 (0.16-0.20)
Total General Surgery Emissions	101.92 (84.00 - 119.84)
Average Emissions by Region	
Atlantic	2.71 (1.73 - 3.68)
Ontario & Quebec	1.44 (1.03 - 1.85)
Prairies	2.00 (1.35 - 2.65)
Pacific	2.72 (2.31 - 3.13)

CI - Confidence Interval; μ - average; $CAD - Canadian Dollars

Figure 2. Total respondent travel costs.

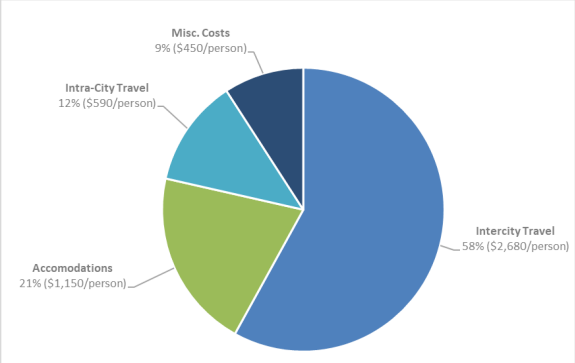


Figure 3. Respondent cost breakdown by category

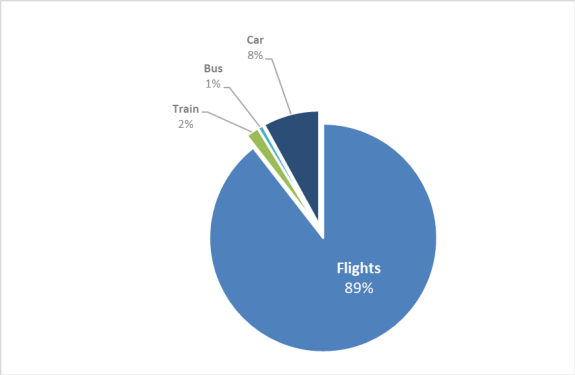


Figure 4. Emissions breakdown by category.

A summary of our regionalized interview models can be found in Table 2. In our Two-City Model, where all applicants travelled to Toronto and Calgary to interview, mean CO_2 emissions per applicant were 1.1 tonnes (95% CI=1.02-1.11), with total applicant CO_2 emissions of 59.7 tonnes (n = 56, 95% CI=57.23-62.11). The total CO_2 emissions associated with a Two-City Model, including travel by delegates, was 84.2 tonnes, which represents a 17.4% reduction from the Current Model (p < 0.001). In a One-City model where applicants travel to Toronto to interview, mean CO_2 emissions per applicant were 0.33 tonnes (95% CI=0.23-0.43), with total applicant CO_2 emissions of 18.6 tonnes (n = 56, 95% CI=12.97-24.28). After factoring in emissions from travel by delegates, a One-City Model would create 57.9 tonnes of CO_2 emissions, which is a 43.2% reduction from the Current Model (p < 0.001).

Table 2. CO_2 emission associated with two-city and one-city models.

	Current Model	Two City Model (Toronto & Calgary)	*p*	One City Model (Toronto)	*p*
Avg Emissions Per Applicant – t (95% CI)	1.82 (1.50 - 2.14)	1.07 (1.02 - 1.11)		0.33 (0.23 - 0.43)	
Total Applicant Emissions (n=56) – t (95% CI)	101.92 (84.00 - 119.84)	59.67 (57.23 - 62.11)	<0.001	18.62 (12.97 - 24.28)	<0.001
Total Delegate Emissions - t (95% CI)	-	24.48 (20.94 - 28.3)		39.31 (33.17 - 45.45)	
Total Model Emissions (*n* = 56) - t (% reduction)	**101.92**	**84.15 (17.4%)**		**57.93 (43.2%)**	

CI - Confidence Interval; t – metric tonnes; μ - average; $CAD - Canadian Dollars

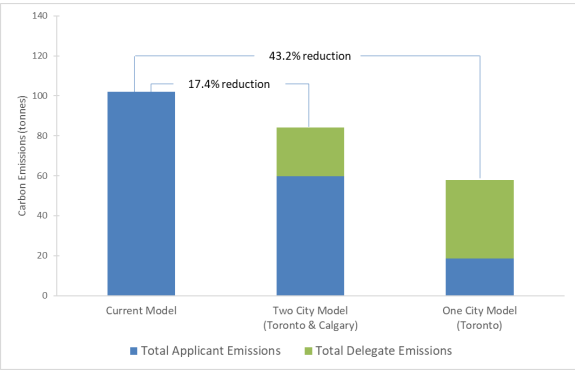
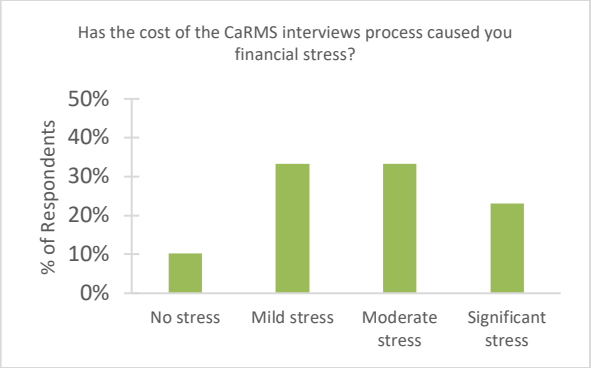


Figure 5. CO_2 emission reductions associated with two-city and one-city models.

Respondents' impressions of travel for residency interviews using Likert scale questions are summarized in Figure 6. Overall, 54% of respondents reported "moderate" to "significant" financial stress related to travel costs for CaRMS, and 75% were "somewhat" or "very" concerned about the global climate impact of travel for CaRMS interviews. When considering alternatives to the current interview system, 46% of respondents "probably" or "definitely" would prefer videoconferencing if they knew it would not affect their application evaluation. Of note, there was a left-skewed distribution to these responses away from a preference for videoconferencing.



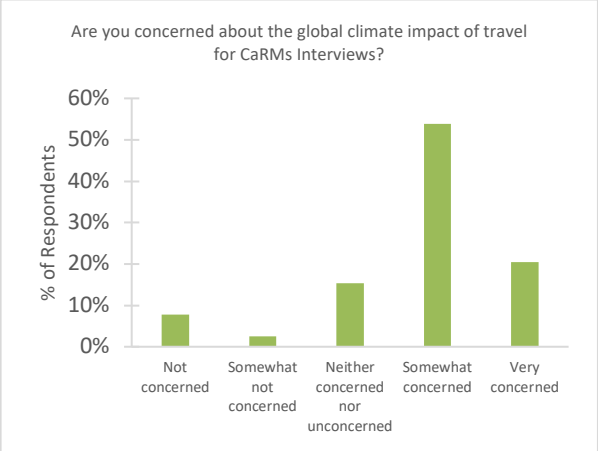


Figure 6. Survey Responses

Discussion

In this survey-based study of Canadian general surgery residency applicants during the 2019-2020 application cycle, travel associated with residency interviews generated approximately 102 tonnes of CO_2 emissions. This is equivalent to the annual emissions from 22 typical gasoline-burning passenger vehicles,[24] or the annual amount of CO_2 sequestration from approximately 990 trees,[22] and is predicted to lead to the loss of approximately 300 square meters of Artic summer sea ice.[25] If interviews were regionalized to one or two-cities, CO_2 emissions could be reduced by 43% and 17%, respectively. If videoconferencing were adopted, CO_2 emissions would be dramatically reduced. Applicants were very concerned about the financial and environmental implications of the residency application process and many were interested in exploring alternatives such as videoconferencing.

A key strength of our study is that we focused on a single specialty. While broader inclusion would have increased the size and diversity of the population, it would have been challenging to recruit a population that is proportionally representative of all Canadian applicants and specialties. Restricting our population to a single specialty creates a homogenous dataset that allows for extrapolation. Furthermore, it allowed for the modelling of an alternative regionalized interview process, as the coordination required for these models is generally only feasible with programs in the same specialty.

Like other survey-based studies, this study is limited by recall bias and self-selection bias. However, the high response rate is reassuring, and the effect of recall bias is generally more relevant in cost estimation than in tracing travel routes. While our convenience sample captures the majority of applicants interviewing at general surgery programs across Canada, there are certainly participants in the general surgery CaRMS match who did not interview at Ottawa, contributing to underestimation of true emissions. Our limited sample size and data precluded any detailed analysis of specific costs per region. As well, IMG international travel was not available, which is presumably a significant contributor to CO_2 emissions given flight distances. The CO_2 emissions reported in this study are rough estimations in that they rely on several degrees of assumptions, including average emission ratings and common travel routes. Indeed, online emissions calculators have been criticized for a lack of transparency in methodology and inconsistent estimates between calculators.[26] Of publicly available CO_2 emission calculators, we chose the MyClimate calculator as its methodology is well described and errs on conservative estimates.[23] While these limitations may affect the accuracy of our emissions estimations, we aimed to maintain precision and reliability by consistently choosing the most conservative model where several options were available.

To our knowledge, this is one of the first studies examining the climate impact of residency applications. Previous studies examining residency applications have predominantly focused on quantifying costs associated with travel and accommodations for both interviews and elective clinical rotations.[12-16] While there have been

several letters and commentaries on the climate impact of physician travel for medical conferences, their emissions estimates have been limited as they did not have the granularity of individual respondent data.[27-31] However the value of these studies cannot be understated as estimates of emissions from conferences are on the order of several thousand tonnes.[31] Many conferences have since begun offering virtual participation and fees to offset CO_2 emissions.[27]

The findings of this study raise a number of important concerns. First, it is important to recognize that this study focuses on a single specialty in Canada, with only 56 applicants interviewing at a mean of 10 programs. In 2018, there were approximately 3000 Canadian Medical Graduates applying to an average of 23 programs.[4] In the 2020 application cycle, 28264 graduating fourth year medical students participated in the National Resident Match Program (NRMP).[32] As our study should be generalizable to most other programs, the true scale of this problem and the potential to reduce CO_2 emissions is likely many folds greater than the results presented here. Given the significant reductions in CO_2 emissions that could be achieved with alternative models, it is important to consider the potential barriers and downsides to these alternatives. Coordinating interview dates and regionalizing interviews has been successfully implemented in many programs, and has been shown to significantly reduce applicant and program costs.[9,17] As well, there have been a handful of pilot studies comparing videoconference interviews with in-person interviews which suggest that there are significant cost-savings without affecting how applicants are ranked.[33-37] The case for videoconferencing is even more compelling when the avoided emissions are taken into account. The findings of the present study indicate that applicants are open to participating in videoconference interviews (Figure 6), however many applicants remain apprehensive about this option. These attitudes may change in the post-COVID-19 era with the increased use of these modalities. Further inquiry into the validity, feasibility, and acceptability of videoconferencing for both applicants and programs is needed.

This study has examined only one culprit of CO_2 emissions related to travel in medical education. It is difficult to quantify the scale of emissions associated with travel by students, residents, and attending physicians for the innumerable standardized examinations, medical conferences, elective rotations, and other medical education activities. As the global climate crisis unfolds, the medical community will need to acknowledge and address its significant carbon footprint in both clinical and educational activities.

Conclusion

This study has estimated the CO_2 emissions associated with travel for general surgery residency interviews and has identified strategies that can significantly reduce—and perhaps even eliminate—CO_2 emissions associated with applications. As these findings should be generalizable to other programs and specialties, the scale of this issue is substantial. While further research is required to examine the implications of these alternative models, the need for urgent and meaningful climate action across all sectors, and the moral imperative for health sector leadership in addressing the climate crisis, mandate a consideration for reform.

Conflicts of Interest: The authors have no conflicts of interest to declare.

Funding: No external funding sources were required for this study.

Author contribution: All authors were involved in the study design; data interpretation; manuscript preparation; and final approval. BF and TL were involved in data acquisition. All authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

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Appendix A. Applicant survey

1. What region are you from?
2. Please list each of your inter-city trips and specify how you got there. Please start with your city of origin (e.g. Ottawa, Montreal, Train). Please feel free to include travel back home between interviews. Please do not include additional non-CaRMs related travel during this period.
3. Approximately how much money did you spend on travel to CaRMS interviews for travel between cities (Flight, Train, Bus, Car, etc.)
    a. 0 - $500
    b. $500 - $1000
    c. $1000 - $1500
    d. $1500 - $2000
    e. $2000 - $2500
    f. $2500 - $3000
    g. $3000 - $3500
    h. $3500 - $4000
    i. $4000 - $4500
    j. $4500 - $5000
    k. $5000+
4. Approximately how much money did you spend for CaRMS for each of the following categories:
   (A) Accommodations (Hotel, AirBnb, etc.) - Total Approximate Cost;
   (B): Travel within Cities (Car, Uber, Taxi, Bus, etc.) - Total Approximate Cost;
   (C) Other Misc - Total Approximate Cost:
    a. $0 - $250
    b. $250 - $500
    c. $500 - $750
    d. $750 - $1000
    e. $1000 - $1250
    f. $1250 - $1500
    g. $1500 - $1750
    h. $1750 - $2000
    i. $2000 - $2250
    j. $2250 - $2500
    k. $2500 - $2750
    l. $2750 - $3000
    m. $3000+
5. Has the cost of the CaRMS interviews process caused you financial stress?
    a. No stress
    b. Mild stress
    c. Moderate stress
    d. Significant stress
    e. Comments:
6. Would you prefer to interview via videoconference instead of in person if it didn't affect how you were evaluated?
    a. Definitely would not
    b. Probably would not
    c. Probably would
    d. Definitely would
    e. Comments:
7. Are you concerned about the global climate impact of travel for CaRMS interviews?

   a. Not concerned
   b. Somewhat not concerned
   c. Neither concerned nor unconcerned
   d. Somewhat concerned
   e. Very concerned
   f. Comments:
8. Please add any additional comments related to CaRMs travel, cost, interview formats, climate impact, or any other concerns.