The Carbon Footprint of Residency Interview Travel

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ABSTRACT

Background Over the last decade, medical student residency applicants have shown a substantial increase in the number of interviews attended, which is associated with a significant increase in travel. The carbon footprint associated with residency interviews has not been well documented prior to this investigation, and is a critical issue related to climate health.

Objective The purpose of this study is to document the carbon footprint associated with travel to residency interviews of the applicants from a single institution.

Methods Graduating medical students from the University of Michigan Medical School were surveyed in 2020 to gather information regarding travel related to residency interviews. A validated carbon emissions calculator was used to determine the associated carbon footprint.

Results Response rate was 103 of 174 (59%). Average interviews per student across all specialties was 14.39 interviews per student. The overall class average for total carbon footprint per student was calculated as 3.07 metric tons CO_2, making the class average carbon footprint per interview 0.21 metric tons CO_2. If we extrapolate the results of our study to all residents, the resulting CO_2 emissions approach 51 665 metric tons CO_2 per year, which is equivalent to the amount of CO_2 produced by 11 162 passenger cars in 1 year.

Conclusions Medical education leaders could help reduce the carbon footprint by encouraging a reduction in number of in-person interviews attended by applicants.

Introduction

In recent years, the residency application process has placed an increasingly large burden on the limited time and finances of fourth-year US medical students. Recent studies have reported significant increases in the average number of applications submitted, length of rank order lists, and costs incurred by medical students over the past decade.[1–3] With an increase in the number of interviews attended and associated travel, we must consider the additional burden of the carbon footprint of this process and its impact on climate health.

The impact of travel (flights in particular) on the carbon footprint of academia is well documented[4–8]; however, there is a paucity of data regarding the impact of residency interviews. Whether by airplane, train, or automobile, the mode of transportation has different effects on the environment. Commercial aviation is the fastest-growing source of greenhouse gas emissions,[9] with total CO_2 emissions from all commercial air flights totaling 918 million metric tons in 2018, representing 2.4% of global emissions.[10] Assessing the carbon footprint of flights is unique compared to other forms of travel in that the relationship between carbon footprint and distance traveled is nonlinear; the ascent and descent of planes use considerably more fuel than cruising at altitude.[11] One study estimated the carbon intensity of flights to be 3.69 to 5.39 ounces CO_2 per revenue-passenger-mile.[10] While these numbers may seem small, the length of travel makes the effect of domestic travel up to 0.75 metric tons of CO_2 per passenger per flight.

The fuel efficiency of motor vehicles varies widely between make, model, and year of manufacture; thus, it is difficult to make broad comparisons about the carbon footprint per distance traveled by car and distance traveled by plane or train. However, regardless of the baseline fuel efficiency of the car, carpooling can drastically reduce the carbon footprint attributed to each passenger; sharing a ride with just one other person will halve the carbon footprint of each rider.[11] Increased occupancy contributes to a lower carbon footprint per passenger of buses and trains, which have lower total carbon footprint per distance traveled than planes and more passenger capacity than cars. However, commercial train and bus routes in the United States are not as extensive or

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Editor's Note: The online version of this article contains the survey used in the study and the specialty demographics of respondents.

widely available for many travel needs; therefore, flights and single occupancy car trips remain the most common options for long distance travel.

This study seeks to elucidate the travel patterns of medical students applying to residency in order to estimate the total carbon footprint of this process.

Objectives
The purpose of this study is to estimate the annual carbon footprint associated with residency interview travel in the United States.

Findings
The average total carbon footprint per student was determined to be 3.07 metric tons CO_2 per interview season; if extrapolated to all graduating students, 51 665 metric tons CO_2 are produced per year as a result of residency interview travel.

Limitations
Extrapolation of study data to all graduating medical students is limited by using data from one institution.

Bottom line
Initiatives to reduce the number of interviews attended by applicants will also serve to reduce the carbon footprint of the residency interview process.

Methods

Graduating fourth-year medical students from the University of Michigan Medical School (UMMS) were surveyed in 2020 to gather information regarding their travel related to residency interviews. The survey was designed to obtain information related to interview travel in order to estimate each individual's carbon footprint (provided as online supplementary data). Data gathered included intended specialty, number of interviews completed, start and end points for all flights, trains, buses, and personal vehicle trips as well as the make, model, and year of vehicles used. Students were each provided a $20 gift card for completion of the survey, provided by an institutional research grant, and all data were deidentified after collection. This study was approved as exempt by the University of Michigan Medical School Institutional Review Board. The survey was reviewed by an education faculty member (W.P.) and a content expert faculty member (J.W.) to assess for clarity, sensibility, and completeness. It was initially administered to a small group of medical students for feedback. The carbon footprint of individual flights and car trips was determined using the Carbon Footprint Calculator for Individuals and Households[12]; the carbon footprint of intercity train trips was calculated using the Greenhouse gases, Regulated Emissions, and Energy use in Transportation (GREET) model.[13] These values were then summed to determine each student's personal carbon footprint. The Carbon Footprint Calculator is independently audited by the quality insurance standard and complies with methodology outlined by the UK government.[14] Verification of air travel carbon footprint data was completed using the ICAO Carbon Emissions Calculator.[15]

In order to calculate individual carbon footprints, the total footprint of one trip by plane, train, or car is divided by average occupancy. The carbon footprint of a trip from Detroit, Michigan, to Denver, Colorado, for example, varies widely by mode of transportation. Traveling by plane produces 0.25 metric tons CO_2 per passenger; by train, 0.19 metric tons CO_2 per passenger; and by car, assuming a 2010 Toyota Camry (a common car reported by students in this survey), 0.52 metric tons CO_2 for one passenger. Class averages of total carbon footprint per student and carbon footprint per interview were calculated. Responses were grouped by specialty type: procedural specialties included all surgical subspecialties, obstetrics and gynecology, emergency medicine, anesthesiology, and dermatology; medical specialties included internal medicine, pediatrics, neurology, physical medicine and rehabilitation, family medicine, psychiatry, and radiology. Further breakdown by travel for preliminary and transitional year positions was also completed. Group averages were compared using a *t* test in Microsoft Excel.

Results

The response rate was 59% (103 of 174), and TABLE 1 shows the breakdown of students by intended specialty. Specialty demographics are included for the respondents and the overall graduating class in the online supplementary data. Average number of interviews per applicant varied widely by intended specialty (9.75–27.33) and individually (3–45); total class average for interviews completed was 14.39. The class average for total carbon footprint per student was calculated as 3.07 metric tons CO_2, making the class average carbon footprint per interview 0.21 metric tons CO_2 (TABLE 2). On average, 76% of the average student's carbon footprint was attributed to flights, followed by car trips (23%) and train trips (1%). Of the 2424 one-way trips to and from interviews completed by applicants, 1326 (55%) were flights, 969 (40%) were car trips, and 129 (5%) were train trips. Most car trips were to cities within 400 miles of Ann Arbor, Michigan, such as Detroit, Chicago, Cleveland, and Pittsburgh. Common travel destinations can be found in TABLE 3.

There was no statistically significant difference in number of interviews attended ($P = .41$), average total CO_2 per student ($P = .77$), or average CO_2 per interview ($P = .99$) between the procedural and

TABLE 1
Specialty Data

Intended Specialty	Responses	Average Interviews (SD)	Average Total CO_2/Student (SD)	Average CO_2/Interview (SD)
Internal medicine	24	12.71 (1.99)	2.85 (1.05)	0.22 (0.08)
Pediatrics	12	13.75 (4.71)	3.40 (1.23)	0.25 (0.05)
Emergency medicine	11	15.18 (3.60)	2.79 (1.23)	0.18 (0.07)
Anesthesiology	10	14.9 (8.12)	2.64 (1.64)	0.17 (0.07)
Urology	7	16.43 (2.51)	3.76 (0.92)	0.23 (0.05)
Obstetrics and gynecology	5	11.6 (3.21)	2.58 (0.99)	0.23 (0.08)
Family medicine	5	16 (6.67)	2.41 (1.09)	0.16 (0.07)
Otolaryngology	4	9.75 (4.11)	1.84 (1.26)	0.18 (0.06)
Neurology	4	14.25 (5.80)	3.18 (1.70)	0.22 (0.03)
Ophthalmology	3	11.33 (5.51)	2.18 (1.34)	0.18 (0.06)
General surgery	3	11.33 (0.58)	3.17 (0.56)	0.28 (0.06)
Dermatology	3	27.33 (15.50)	5.89 (4.00)	0.21 (0.05)
Physical medicine and rehabilitation	2	17.5 (3.54)	3.18 (0.73)	0.19 (0.08)
Orthopedic surgery	2	14 (2.83)	3.09 (1.12)	0.22 (0.04)
Pediatric neurology	2	10.5 (0.71)	3.09 (0.63)	0.30 (0.08)
Neurological surgery	1	17 (N/A)	4.67 (N/A)	0.27 (N/A)
Plastic surgery	1	13 (N/A)	3.43 (N/A)	0.26 (N/A)
Psychiatry	1	16 (N/A)	5.19 (N/A)	0.32 (N/A)
Radiology	1	33 (N/A)	3.38 (N/A)	0.10 (N/A)
Triple board	1	12 (N/A)	2.91 (N/A)	0.24 (N/A)
Vascular surgery	1	22 (N/A)	7.32 (N/A)	0.33 (N/A)

Abbreviation: N/A, not applicable.
Note: For average CO_2 data, units are in metric tons CO_2.

medical specialties; this finding was robust even after outliers, defined as students with number of interviews greater than 3 standard deviations above the mean, were removed. Averages for each specialty are displayed in TABLE 2. Of the 19 students applying to specialties requiring a transitional or preliminary year such as anesthesia, neurology, dermatology, or physical medicine and rehabilitation, 14 students provided detailed information regarding their travel to interviews dedicated to transitional or preliminary year positions. The average carbon footprint of interviews for these 14 students was 3.36 metric tons CO_2 with an average of 0.61 metric tons of CO_2 (13%) attributed to transitional or preliminary year interview travel alone. There was no statistically significant difference in number of interviews ($P = .17$), average total CO_2 per student ($P = .56$), or average CO_2 per interview ($P = .99$) between this group and all other applicants.

TABLE 2
Class Averages

Class Average	mT CO_2 (SD)
Total CO_2/student	3.07 (1.45)
Total interviews	14.39 (5.69)
CO_2/interview	0.21 (0.07)
Total flights	12.93 (7.02)
CO_2 flights	2.32 (1.43)
Total car trips	9.41 (7.60)
CO_2 cars	0.71 (0.60)
Total train trips	1.25 (2.15)
CO_2 trains	0.04 (0.08)

Abbreviations: mT, metric tons.
Note: For average CO_2 data, units are in metric tons CO_2.

Discussion

In this study, we determined that the carbon footprint of residency interview travel is considerable, with the majority accrued from air travel. Our results are timely given that as a result of the COVID-19 pandemic, all interviews during the 2020–2021 academic year have been virtual. If we extend the results of this study to estimate the total CO_2 emissions saved by this decision, using the population of all 18 925 US seniors who participated in the 2019 Match[16] and assuming an average of 13 interviews[17] and 0.21 metric tons CO_2 per interview, the resulting value would be 51 665 metric tons CO_2. This is

TABLE 3
Common Locations and Modes of Travel

Common Locations Traveled to by Plane			
City	**Students**	**Miles**	**mT CO_2**
Boston	56	632	0.14
Denver	41	1123	0.25
New York	39	509	0.11
Philadelphia	39	453	0.11
Baltimore/Washington, DC	39	409	0.09
Seattle	38	1927	0.43
San Francisco	36	2079	0.46
Atlanta	35	594	0.13
Raleigh/Durham	33	501	0.11
Minneapolis	32	528	0.12
Common Locations Traveled to by Car			
City	**Students**	**Miles**	**mT CO_2**
Chicago	55	241	0.10
Detroit/Royal Oak	53	44	0.02
Pittsburgh	36	286	0.11
Cleveland	35	169	0.07
Madison	25	395	0.16
Columbus	24	189	0.08
Indianapolis	13	266	0.11
Cincinnati	9	250	0.10
Milwaukee	7	332	0.13
Nashville	5	522	0.21
Common Locations Traveled to by Train			
City	**Students**	**Miles**	**mT CO_2**
Chicago	30	241	0.04

Abbreviations: mT, metric tons.
Note: Values for miles traveled and associated metric tons CO_2 represent one-way trips. Metric tons CO_2 produced traveling to locations by car were calculated assuming a 2010 Toyota Camry was used.

equivalent to the amount of CO_2 produced by 11 162 passenger cars in 1 year.[18] Given these results, we argue that reducing the travel burden on residency applicants during the eventual transition back to in-person interviews is a relatively simple tangible way to contribute to the goal of reducing the carbon footprint of academic medicine and the health care system as a whole.

This work adds to the growing literature on the need to reduce the burden of excessive interviewing. Some recent proposals to address this problem, such as the early result acceptance program (ERAP),[19] may also serve to reduce the environmental effects of the residency application process by reducing travel. The ERAP proposes to allow students to apply to, interview at, and rank up to 5 programs before the traditional Match. If 25% of US allopathic seniors (4731 of 18 925) participated in and successfully matched through an early Match system, assuming a reduction in interviews for those applicants from 13 (median reported from NRMP)[17] to 5, we would expect to see a 15% decrease in overall carbon footprint for the Match (43 717 metric tons CO_2). The decrease of 7948 metric tons CO_2 is equivalent of taking 1717 passenger cars off the road for 1 year.[18] In the 2020 Match, all obstetrics and gynecology residency programs adhered to a standardized calendar for application deadlines as well as interview offer and rejection dates in order to simplify the process for applicants and programs.[20] With a more standardized scheduling process, students would be able to more efficiently cluster interviews by geographic location and to judiciously choose which interviews to attend, thus potentially reducing overscheduling and total travel.

While some alternatives to the current Match process may require broader institutional change, there are many relatively simple changes that can be made by residency programs to reduce interview-related travel and thus carbon emissions. Prior to the COVID-19 pandemic, many programs offered transitional/preliminary year candidates virtual interviews or added brief interviews to their categorical program interview day. If virtual interviews for transitional/preliminary year positions were continued, it could reduce the total carbon footprint of this population of 13 140 students[21] from 35 872 metric tons CO_2 to 31 208 metric tons CO_2, assuming 13 interviews per applicant and a 13% reduction as suggested by the data, which is equivalent of taking 1008 passenger cars off the road for 1 year.[18] Many specialties encourage or require students to complete visiting rotations at other institutions before applying. A survey of US applicants for residency in the 2014–2015 academic year suggested that approximately 60% of all fourth-year medical students completed at least one away rotation.[22] If all such programs interviewed candidates during their away rotations, it could also serve to reduce students' carbon footprint and travel burden.

This study is limited in its ability to extrapolate the results of this analysis to the total population of US allopathic seniors, as data were collected from only one medical school class, which is unlikely to be completely representative of all graduating US medical students. The University of Michigan Medical School is among the top 25 programs in the nation per *US News & World Report*,[23] and many students are offered interviews across the country. Additionally, the UMMS program is located in the Midwest, and therefore coastal destinations require increased travel compared to students already situated on the coasts. Since many UMMS students interview at one or more coastal programs,

the resulting average carbon footprint calculated from this data may be an overestimation. Future similar studies from other schools would be invaluable to accurately assess the national environmental impact of this process. In addition, there were insufficient sample sizes in many individual specialties represented by the survey, which limited comparisons that could be made about differences in travel habits and carbon footprint among applicants to different specialties.

The environmental impact of residency interviews must be considered, and this work adds to multiple calls to improve residency application processes. As we transition to in-person interviews in future cycles, viable alternatives that decrease the number of interviews attended by applicants need to be prioritized. Reforming the residency application and interview process can serve multiple beneficial roles, reducing the burden on both applicants and the environment.

Conclusions

Converting all interviews during the 2020–2021 academic year to a virtual format reduced the carbon footprint of the residency application process by 51 665 metric tons CO_2. Practices to reduce the number of interviews attended and thus the total carbon footprint include an early result acceptance program, standardizing interview invitation schedules, and maintaining virtual interviews for some positions.

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