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Research article

Pediatric telemedicine visits reduce greenhouse gas emissions

David F. Grabski[a], Matthew J. Meyer[b], Jeffrey W. Gander[c,*]

[a] Department of Surgery, University of Virginia School of Medicine, USA
[b] Department of Anesthesiology, University of Virginia School of Medicine, USA
[c] Division of Pediatric Surgery, University of Virginia School of Medicine, USA

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ABSTRACT

Introduction: The planet is facing a substantial crisis of global warming from the burning of fossil fuels. The global healthcare system contributes to 4.4 of global emissions part of which can be attributed to patient travel. Telemedicine has the opportunity to provide care while obviating the need for travel. We hypothesized that the use of pediatric telemedicine will decrease carbon emissions.

Methods: We performed a review of a prospective electronic medical record system of all children that presented to an outpatient children s hospital center from August 2019 through February 2022. The primary outcome was the number of telemedicine visits that occurred per month during the time period. The home zip code for each patient was included and used to calculated the median round trip distance to travel to the outpatient clinic. The EPA greenhouse gas equivalents calculator was utilized to convert car emissions data to carbon dioxide (CO2) emissions data.

Results: Over the investigation period, there were 20,845 pediatric telemedicine visits. The travel distance that was eliminated was 1,562,716 miles (roundtrip). Using an estimate of 22.5 miles per gallon, this represents a savings of 69,454 gallons of fuel, which translates to 618 metric tonnes of CO2 saved.

Conclusion: In children, telemedicine can decrease time away from school, work for parents, need for childcare, as well as the cost and time for travel. Pediatric telemedicine use can bene t the environment through the substantial reduction of carbon dioxide emissions.

Introduction

The National Aeronautics and Space Administration (NASA) was one of the rst users of telemedicine technology in the 1960s [1]. However, telemedicine s wide spread adoption in the United States only recently expanded due to the COVID-19 pandemic. Medicare telemedicine visits increased from 840,000 in 2019 to over 52,000,000 in 2020 [2]. Concomitantly with the COVID-19 pandemic, the planet is facing a substantial crisis of global warming. Carbon dioxide levels have risen from 280 parts per million (ppm) to 417 ppm over the last 151 years, primarily from the burning of fossil fuels [3]. Carbon dioxide and other greenhouse gases are felt to be the primary driver of global warming and subsequent instability of our environment.

The global health care system contributes to 4.4 of global emissions. While varying by country, the burning of fossil fuels to travel to a health care facility contributes to this. As an example, the National Health Service contributes 25 million tonnes (metric ton = 2204 pounds) of carbon emissions per year of which 10 can be attributed to patient travel [4,5]. Telemedicine has the unique opportunity to provide care while reducing the need for travel.

Previous studies have suggested decreased emissions with the use of telemedicine in adult clinics. A geriatric medicine clinic estimated a savings of 200 kgs of C02 emissions over a year [4]. Paquette studied a vascular surgery clinic and found savings of 1632 kg of carbon dioxide, 42,867 g of carbon monoxide, 3160 g of nitric oxide and 4715 g of volatile organic compounds over a 2-year period. Additionally, they reported 194 gallons of gas saved [6]. A recent study from a pediatric surgical and anesthesia group showed a savings of 688,317 pounds of carbon dioxide over a one year period [7].

At our health system, telemedicine use became widespread in March 2020. Pediatric outpatient services use of telemedicine expanded exponentially during that time. This article examines the effects of pediatric telemedicine on travel and carbon emissions savings.

Methods

We performed a review of the electronic medical record system of all children that presented to an outpatient children s hospital center

Abbreviations: EPA, environmental protection agency; mpg, miles per gallon; CO_2, carbon dioxide

* Corresponding author at: Department of Surgery, Division of Pediatric Surgery, 1204 W Main Street, Charlottesville VA 22903, 434-924-2673, USA.
E-mail address: jg9br@uvahealth.org (J.W. Gander).

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from August 2019 through February 2022. Our medical center is an academic quaternary medical center with an integrated children s hospital and a stand-alone children s outpatient center that is on the hospital campus. Our hospital is situated in a rural area with a standard catchment area of approximately 300 miles. The investigation included all children aged 0 18 years old that were scheduled for a telemedicine clinic visit at the outpatient clinic over the study period. No patients were excluded based on medical subspecialty, presenting diagnosis or acuity of visit.

During the COVID-19 (COVID) outbreak, our health system eliminated all non-emergent outpatient visits on March 31, 2020. In place of outpatient clinic visits a telemedicine platform (Webex) was introduced throughout our health care system. There was a strategic reintroduction of elective clinic visits over the ensuing 6 months. The strict restrictions on emergent clinic visits remained in place until May 21, 2020 at which time remote registration for the outpatient center was allowed and select urgent and elective cases were reintroduced. On August 21, 2020, the outpatient clinic returned to full elective visits and allowed 2 designated visitors for each pediatric clinic visit. Some form of mild restriction lasted throughout our health system, including the outpatient children s clinic, until June 2021 where all public hospital spaces were re-opened.

To analyze the effect of the policy, we included a pre-intervention cohort form August 2019 through March 2020 to capture the number of telemedicine visits that occurred prior to the COVID-related policy changes. The intervention period was designated from March 31, 2020, when the policy began through June 01, 2021 when all visitor restrictions were liberalized. We also included a post-intervention cohort from June 02, 2021 through February 01, 2022 to determine if a practice change occurred in our health center as a result of the COVID policy.

The number of telemedicine visits performed through the outpatient children s hospital each month during the study period was calculated. A time-series plot was created to evaluate the utilization of telemedicine visits before, during, and after the policy interventions. The Mann-Kendall statistical test was used to calculate whether a signi cant time trend was associated with our data. A p-value of 0.05 was considered signi cant. Statistical analysis was conducted in R (Version 4.0.5).

The amount of greenhouse gas emissions savings that resulted from telemedicine visits in place of traveling to the outpatient clinic for a period of one year starting on March 31, 2020 was calculated. To perform the calculation, the home zip code for each patient in the investigation was included and used to calculate the median round-trip distance required to travel to the outpatient clinic. The United States Environmental Protection Agency (EPA) estimates that the average United States car has a highway mile to the gallon (mpg) requirement of 22.5. The EPA greenhouse gas equivalents calculator was then utilized to convert car emissions data to carbon dioxide (CO2) emissions data (https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator). The CO2 emission data was calculated for one full calendar year following the COVID policy intervention to estimate a yearly average. To demonstrate the distribution of patients presenting to our outpatient children s hospital, a heatmap was created of the state of Virginia over one a year period. Increased density represents increased number of patients presenting from a speci c zip code.

This project was determined to be a quality improvement initiative and was exempt from institutional board review.

Results

Over the 31-month investigation period, 20,845 pediatric telemedicine visits occurred at our outpatient pediatric hospital. Approximately 58 of patients were male and the median age of patients was 8 years old (range 0 18). White Non-Hispanic children represented 77 of the patient population, African-American children represented 12.9 and Asian children represented 1 of the total patient population. The most common divisions for telemedicine visits were general pediatrics (51.8), pediatric endocrinology (10.4), pediatrics gastroenterology (8.4) and adolescent medicine (6.9), though all subspecialities, including surgical subspecialities, were included. In the year prior to clinic restrictions, the demographics of in person visits were similar. However, the percentage of specialty types were different as the most common were general pediatrics (18), pediatric orthopedic surgery (8.2) and pediatric cardiology (7.9).

The restrictions of in-person clinic visits that resulted from our COVID policy implemented on March 31, 2020 directly increased the number of telemedicine visits for children at our institution. In the 6-month period prior to the COVID policy (pre-intervention cohort) there were 35 telemedicine visits associated with the outpatient clinic. In April 2020, the number of telemedicine visits increased to 1329 visits. Restricted in-person outpatient clinic visits began in mid-May 2020, and the trend of increased utilization of telemedicine visits continued in June with 1007 visits in July and 857 visits, for example. As noted previously, some form of visitor restriction from institutional COVID policy existed through June 2021 (intervention cohort). The average number of telemedicine visits over this restricted period was 948 telemedicine visits per month. A time series of telemedicine visits by month is provided in Fig. 1. The time

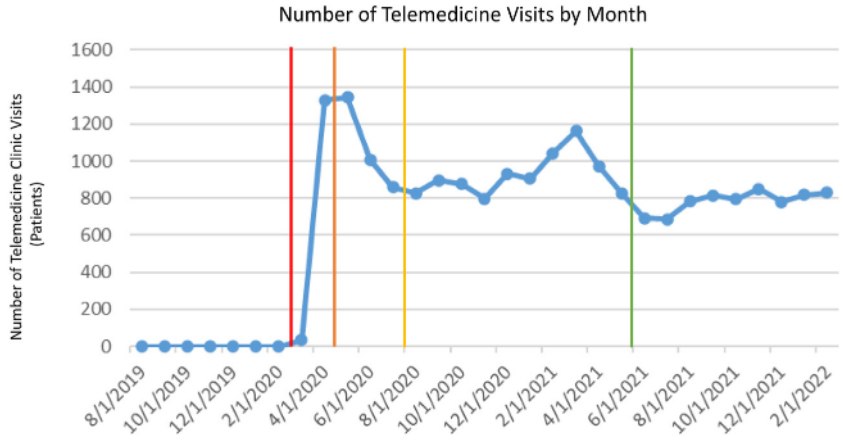

Fig 1 Number of telemedicine visits at the outpatient pediatric hospital per month. The number of telemedicine visits per month are represented on the y-axis. The study period by month is represented on the x-axis. The red vertical line represents the beginning of the COVID mandate for telemedicine visits (March 2020). The orange vertical line (May 2020) represents the date when remote registration was re-introduced at the outpatient clinic. The Gold line (August 2020) represents the data when as close to a full return of elective visits were allowed. The green line (June 2021) is when COVID restrictions ended including unrestricted access to hospital public spaces and temperature screening was stopped. The time series data demonstrated a statistically signi cant increase in telemedicine visits (Mann-Kendall Test, tau=0.345, *P* 0.0001).

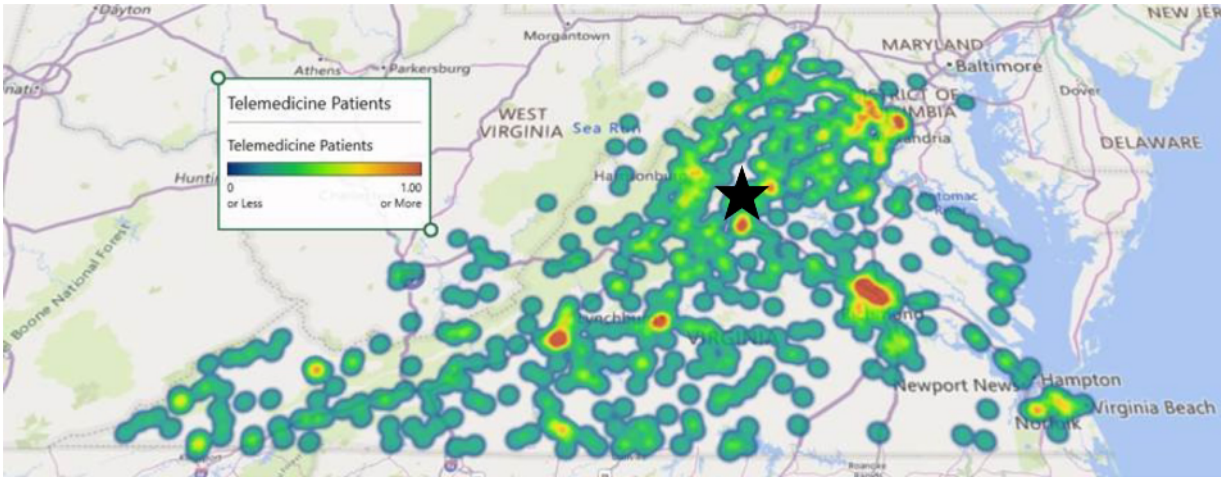

Fig 2 Heatmap of the State of Virginia. Density of the map represents patient s presenting to the pediatric outpatient hospital from different zip codes across the state. Blue-green represents low density. Yellow-red represents high density. The gure represents all patients who presented to the outpatient hospital from March 2022 (start of COVID visitation policy) to May 2022 (when remote registration was re-instated). Star denotes site of clinic in Charlottesville.

series data demonstrated a statistically signi cant increase in telemedicine visits (Mann-Kendall Test, tau= 0.345, *P* 0.0001) when comparing August 1, 2019 March 30 2020, to March 31, 2020 June 1, 2021. Additionally, the data of this investigation demonstrated that following liberalization of in-person clinic visits in July 2021, the utilization of telemedicine visits persisted through the end of the study period in February 2022 (post-intervention cohort). In this post-intervention period, the average number of telemedicine visits per month was 792.

The 1-year greenhouse gas emissions savings that occurred secondary to the COVID policy restriction on in-person clinic visits was calculated based on the estimated distance traveled to the hospital by each patient. The travel distance that was eliminated over the year following the COVID policy was 1562,716 miles (roundtrip). A heatmap of patients that participated in telemedicine visits from various zip codes across Virginia is presented in Fig. 2. With an estimate of 22.5 miles per gallon (EPA estimated for average US car), this represents a potential savings of 69,454 gallons of fuel. Based on the EPA model, this represents a yearly saving of 618 tonnes of CO2. Using the Bureau of Transportation Statistics website, we calculated a reduction of 5.4 tonnes of carbon monoxide and 0.67 tonnes of nitric oxide [8]. Additionally, we saved 16.1 tonnes of volatile organic compounds [6].

Discussion

The COVID-19 pandemic led to a dramatic increase in the use of telemedicine in our pediatric outpatient clinic. An important bene t of telemedicine is reducing the amount of greenhouse gas emissions caused by travel to and from a healthcare provider." In our study, 1,562,716 miles traveled were eliminated by utilizing telemedicine in the rst year after COVID restrictions were instituted. This translated into an elimination of 618 tonnes of CO2 and the saving of 69,454 gallons of fuel. Even after restrictions were lifted, the utilization of telemedicine was sustained.

Previous studies in adult patients have demonstrated that telemedicine has the ability to reduce greenhouse gas emissions [6,9 14]. In a pilot study, a teledermatology clinic in the UK saved 680 kg of carbon dioxide over 5 months [15]. Sellars et al. in a colorectal clinic, saved 6685 miles of travel [16]. Finally, a systematic review of 14 studies showed signi cant carbon dioxide reductions when telemedicine was used [17].

There is a paucity of data on the amount of greenhouse gases saved in a pediatric telemedicine setting [7]. An important consideration is that many pediatric specialists in the United States are located in children s centers and thus travel distance can be considerable for some patients. For example, there are only 5 pediatric general surgery groups in Virginia which cover 42,755 sq. miles. Thus, the use of telemedicine in pediatric settings, especially specialists, can save a considerable amount of greenhouse gases.

The American Medical Association has adopted a policy declaring climate change a public health crisis [18]. Additionally, the World Health Organization has referred to climate change as the single biggest health threat facing humanity. This is due to the increase in heat related injuries, vector borne diseases and air pollution leading to respiratory illnesses. Additionally, climate change can lead to famine and reduction in food security.

Healthcare systems around the world, including in the United States, contribute to climate change. This is estimated to be 4.4 of global emissions. The United States healthcare system contributes 8.5 of US carbon emissions [19]. To combat this, the National Academy of Medicine has undertaken an initiative to decarbonize the US healthcare system. They are working to do this in four domains: health care supply chain, health care delivery, health professional education and policy. Telemedicine can help to decarbonize health care while still delivering effective care [6,9 14].

Despite lifting visitation restrictions, the use of telemedicine in our center was sustained, suggesting that it is here to stay. This gives promise that the continued use of telemedicine may further help reduce carbon emissions throughout US healthcare.

We recognize that our study does not take into account emissions needed to build the infrastructure for telemedicine. However, previous studies have suggested that the emissions saved far out-weigh the greenhouse gases utilized [17]. Additional limitations are that we assumed all patients drove to their clinic visit. It is possible some who lived in Charlottesville walked to their visit or used the bus. The average mileage per gallon for a bus is 8 10, so this likely would cancel out any decrease in fuel saved from the patients who walked.

Conclusion

Telemedicine has numerous reported bene ts. In children, it can decrease time away from school, work for parents, need for childcare as well as the cost and time for travel. This study quanti ed an added bene t to the environment through reductions in carbon dioxide emissions, making an even stronger case for the use of telemedicine for any suitable pediatric patient."

Contributors statement page

Dr Jeffrey Gander and Dr. David Grabski conceptualized and designed the study, designed the data collection instruments, collected data, carried out the initial analyses, drafted the initial manuscript, and critically reviewed and revised the manuscript.

Dr Matthew Meyer critically reviewed and revised the manuscript.

All authors approved the nal manuscript as submitted and agree to be accountable for all aspects of the work.

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Declaration of competing interest

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

CRediT authorship contribution statement

David F Grabski: Writing review & editing, Writing original draft, Formal analysis, Conceptualization. **Matthew J Meyer:** Writing review & editing. **Jeffrey W Gander:** Writing original draft, Supervision, Formal analysis, Conceptualization.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.joclim.2024.100309.

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