Telehealth: Reducing Patients’ Greenhouse Gas Emissions at One Academic Psychiatry Department

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Abstract

Objective Academic and organizational leaders in psychiatry and all other medical fields are negatively impacted by climate change. The COVID-19 pandemic prompted a rapid shift to the use of more telehealth by behavioral health clinicians. The purpose of this study was to estimate the reduction of patients’ greenhouse gas emissions during this rapid shift at one academic psychiatry institution.

Methods The authors extracted data associated with all outpatient visits to all 26 psychiatry clinics from March 16, 2020, to December 31, 2020. Once the patients’ travel miles saved by confirmed virtual visits were calculated, the authors used the standard ratio from the US Environmental Protection Agency (EPA) to calculate the total quantity of CO\(_2\) that would be emitted if the visits had occurred in person.

Results During the study period, a total of 47,582 outpatient behavioral health visits with 3975 unique patients were completed. The majority of these departmental visits were telehealth (85%), with most of the telehealth visits conducted using real-time audio-video platforms (75.7%). Subtracting emissions from patient technology during telehealth visits from the estimated patient transport values produced a net savings of greenhouse gas emissions of 867,011 kg CO\(_2\). This amount is equal to the greenhouse gas emissions from 189 passenger vehicles driven for 1 year according to the EPA.

Conclusions This study shows that converting in person, face-to-face behavioral health visits to telehealth has the potential to increase both energy efficiency and conservation through a reduction in greenhouse gas emissions due to reduced patient travel. If these values were extrapolated to the total adult US population who have visits for behavioral health reasons, we estimate that conversion to virtual visits could save approximately 830,000 metric tons of CO\(_2\) annually. Organizational leaders should consider these societal benefits when making decisions regarding development and support of telehealth.

Keywords Telehealth \(\cdot\) Climate change \(\cdot\) Greenhouse gas emissions

Climate change is “the biggest global health threat of the 21st Century” according to *Lancet* and the University College of London Institute for the Global Health Commission [1]. In September of 2021, more than 200 medical journals published an editorial warning “the greatest threat to global public health is the continued failure of world leaders to keep the global temperature rise below 1.5° C and to restore nature.” [2] For behavioral health, the consequences of severe weather events lead to higher rates of clinical disorders, including anxiety, depression, post-traumatic stress, substance use, and suicidal thoughts [3]. Unfortunately, children, older adults, low-income communities, and communities of color are disproportionately affected by and are less resilient to the health impacts of climate change [4]. The global health care industry is currently responsible for 4.4% of worldwide net emissions and would be the world’s fifth-largest emitter of greenhouse gases, if the sector was a country [5]. The US health care system is responsible for about a quarter of all global health care greenhouse gas emissions, which is more than the health care system of any other nation [5]. Carbon dioxide (CO\(_2\)) is the primary greenhouse gas emitted in the USA (80%), with the majority coming from transportation (35%) and electricity (31%) [6]. Increasing energy efficiency and energy conservation are two strategies the US Environmental Protection Agency (EPA) promotes for reduction of CO\(_2\) emissions. An
Academic Psychiatry editorial in 2018 initiated a call to action to develop initiatives to reduce the carbon footprint of psychiatry, but interventions have been limited in scope and challenging to analyze [7].

The COVID-19 pandemic accelerated a transformation in behavioral health care delivery through widespread adoption of telehealth services. A recent Medicare report revealed telehealth visits increased 63-fold, from approximately 840,000 in 2019 to nearly 52.7 million in 2020 [8]. Behavioral health specialists accounted for the largest increase in the number of telehealth visits [8]. Some articles have proposed the use of telehealth reduces personal transportation-related greenhouse gas emission at a rate greater than the increased demand of electricity required for telehealth, although this has not been adequately studied [9]. The purpose of this study was to calculate the miles not driven by patients and therefore better estimate the greenhouse gas emission reduction at one academic medical center during the rapid shift to telebehavioral health. We hypothesized that the transition to virtual care would lead to substantial reductions in greenhouse gas emissions due to transportation, thus suggesting to health care organizational leaders that support of virtual care could contribute to efforts to combat climate change.

Methods

The overall study and methods were approved by the University of North Carolina-Chapel Hill Institutional Review Board. The authors extracted data associated with all outpatient visits to psychiatry clinics from March 16, 2020, to December 31, 2020. March 16, 2020, was the first day UNC Department of Psychiatry started the process of pivoting to virtual care. The extracted variables associated with each visit are patient residential address, geographic coordinates (latitude and longitude), visited clinics and their addresses, visit date, and visit type (modality). Visits were grouped as in person or virtual care. The following were coded as virtual care: audio-only (telephone), real-time audio-visual (video), and group visits. Group visits were coded as virtual care because they were conducted in the form of video conference since the start of the COVID-19 pandemic. All other visit types not coded as virtual care were coded as in person.

For missing geo-coordinates, the authors used ArcGIS Pro version 2.7 to geocode the addresses of patients. Geocoding is a process that assigns geographic coordinates (latitude and longitude) to individual addresses. The study geocoded the addresses of the 26 psychiatric clinics corresponding to each location. Once the addresses of patients and the clinics were geocoded, the authors used the Network Analysis extension of ArcGIS Pro to calculate the travel distance (miles) and time (minutes) between the geolocations of the patients’ homes and clinics. ArcGIS calculates the travel distance and time as a full combination between the two sets of geocodes. Once obtained, the study merged the results of the ArcGIS calculations with the real patient visits data to get the results based on the materialized virtual visits.

Patients were excluded from the study if no address was captured in the system. Patients whose addresses were outside North Carolina were excluded because (1) they may use a different mode of transportation to visit the clinics, and (2) the listed address in the system may not be their residential address. Patients whose address was listed as homeless or unhoused were excluded from the study population due to the inability to calculate travel distance. If a nonphysical address (e.g., post office box (P.O. Box)) was listed as the address, the geo-coordinates of the centroid of the city associated with the P.O. Box were used as the default home addresses for the patients. The assumption is that the uncertainties of the exact addresses would cancel each other out during the aggregation.

Once the travel miles saved by confirmed virtual visits were calculated, the authors used the standard ratio (see below) from the US EPA (an average passenger vehicle emits about 404 g of CO2 per mile) to calculate the total quantity of CO2 that could be emitted if the visits were in person [10].

Avoided Carbon Dioxide (kg)

\[
\text{Avoided Carbon Dioxide (kg)} = \frac{404g \times \text{Distance (mile)} \times 2}{1000}
\]

Tableau 2021.3 was used for data management, descriptive statistics, and visualization.

Estimates for greenhouse gas emissions used during virtual visits by patients using technology was calculated using published estimates. Audio-only visits were assumed to be conducted by patients using mobile smartphones, as the authors felt this would represent the most conservative estimate of greenhouse gas consumption. Using the published value of 63 kg of CO2/year of emissions if using a smartphone for 1 h per day, the authors calculated smartphone emissions per minute used as 0.0028 kg CO2-eq [11]. This value was multiplied by the total estimated audio-only visit duration in minutes to calculate excess greenhouse gas emissions created by completing audio-only visits. For real-time audio-video visits, the study was unable to clearly determine what type of technological device patients used to complete the visit. However, based on tracking of one teaching clinic over a 4-week period and informal discussions with clinicians, we conservatively estimated that 75% of patients used a smartphone to complete their visit, while 25% used a laptop or desktop computer. Of those that used a computer, we estimated that 75% of those individuals used a laptop, while 25% used a desktop. We used published estimates of the amount of greenhouse gas emissions created from desktop (21.8 kg CO2-eq/year) and laptop (11.0 kg CO2-eq/year) computers to determine the amount of emissions per minute of device use (0.0000416 kg CO2-eq
and 0.000021 kg CO₂ eq, respectively) [12]. The authors then multiplied this value by the total estimated real-time audio-video visit durations in minutes to calculate excess greenhouse gas emissions created by completing audio-video visits.

### Results

For all outpatient visits to psychiatry clinics from March 16, 2020, to December 31, 2020, a total of 47,582 outpatient behavioral health visits with 3975 unique patients were completed. A total of 4 patients who had a total of 90 virtual visits were listed as “homeless” or did not have home address information and were removed from the study. The range of travel distances among all patients who visited the psychiatric clinics varied from the shortest distance of 0.1 miles while the longest distance was 320 miles. On average, each patient had 10.19 visits during this period and the vast majority of the psychiatry department’s visits were telehealth (85%). The majority of telehealth visits were conducted using real-time audio-video platforms (75.7%) with the remaining being conducted using audio-only (telephone, 24.3%). Patients residing in 95 of the 100 counties in the state of North Carolina participated in telehealth appointments during the study period. Overall, conversion to telehealth appointments saved 1,079,541 miles of travel, with the average savings per encounter of 27 miles (range 0.1–324.2 miles) (Table 1). Travel distances saved varied greatly by clinic, with the longest being 66.0 miles for a clinic dedicated to treating a medically complex patient population (i.e., solid organ transplant patients), and the shortest being 5.8 miles for a community mental health clinic in a suburban setting. An estimated 872,266 kg CO₂ from patient transport were saved by conducting telehealth visits during this time frame, with a savings per encounter of 22 kg CO₂. Overall, the number of virtual visits increased over time, with a correlated increase in travel emissions saved (Fig. 1).

Average visit times using virtual technology were similar, regardless of modality (audio-only = 48.7 min, real-time audio-video = 52.0 min). Estimated increased patient emissions from technology use to facilitate telehealth encounters totaled 1501 kg CO₂ for audio-only visits and 3754 kg CO₂ for real-time audio-video encounters. Subtracting emissions from patient technology during telehealth visits from the estimated patient transport values produced a net savings of greenhouse gas emissions of 867,011 kg CO₂ through utilization of telehealth during this period.

### Discussion

This study shows that converting in person behavioral health visits to telehealth has the potential to increase both energy efficiency and conservation through a reduction in greenhouse gas emissions due to reduced patient travel. The travel distance saved by using virtual visits varied by clinic, with those clinics providing more specialized psychiatric care requiring patients to travel longer distances, and those focused on community behavioral health having the shortest distances saved. In our relatively large sample, 872 metric tons of CO₂ were saved in the 9 months of our analysis, which extrapolates to approximately 1162 metric tons of CO₂ annually. If these values were extrapolated to the total adult US population who have behavioral health visits annually, we estimate that conversion to virtual visits could save approximately 830,000 metric tons of CO₂ annually [13, 14]. While this value is a small fraction of the total greenhouse gas emissions due to transportation in the USA annually (~1875 million metric tons), telehealth represents a tangible and easily feasible means of reducing overall greenhouse gas emissions [8]. In addition, 830,000 metric tons of CO₂ saved would be the estimated equivalent of 93 million gallons of gasoline saved annually [6]. While these contributors to improved climate health may be small in the grand scheme of things, given the complexity and enormity of climate change, numerous solutions will be needed to address it.

To complete this study, the authors made several assumptions. The authors made assumptions regarding the types of devices patients used for virtual visits based off informal recollections/reports from clinicians. This introduces recall bias into our results, which could shift the estimated greenhouse gas emissions due to patient device usage. However, because the greenhouse gas emissions from patient devices is orders of magnitude less than emissions due to transportation, we would not expect this to substantially impact our findings.

### Table 1 Types of appointment and estimated emissions saved

| Visits (%) | Miles saved | Avg. miles saved per visit | Travel emissions saved (kg CO₂) | Avg. travel emissions saved per visit (kg CO₂) | Avg. visit time (min) | Excess tech. emissions (kg CO₂) | Net emissions (kg CO₂) |
|------------|-------------|---------------------------|--------------------------------|-----------------------------------------------|----------------------|-------------------------------|-----------------------|
| All virtual | 40,474 (N/A) | 1,079,541                 | 27                             | −872,266                                      | 51.8                 | 5255                          | −867,011              |
| Audio-only  | 9818 (24.3)  | 240,174                   | 24                             | −194,062                                      | 48.7                 | 1501                          | −192,561              |
| Real-time audio-video | 30,656 (75.7) | 839,366                   | 27                             | −678,204                                      | 52.0                 | 3754                          | −674,450              |
The authors assumed patients would travel from and back to the addresses listed in the system and that patients would not make multiple visits in 1 day. If patients started from somewhere other than their home address, this was not captured in the system and would alter the calculations/estimates. The study assumed all patients drove gasoline cars and yet some may have driven electric vehicles or used public transportation. Recent data from 2019 indicated 0.1% of the existing vehicle fleet in North Carolina was electric, making this a reasonable assumption [15]. North Carolina has a relatively low use of public transit, the vast majority of which utilize diesel-fuel buses. Estimates of public transit use in the immediate vicinity of the largest psychiatry clinic included in this study are around 10–12%. Given that the vast majority of patients reside outside of the immediate vicinity of the clinics, it was assumed that the amount of emissions offset by public transit use is negligible [16]. The authors’ estimates were based on distance and standardized estimated potential CO₂ emissions, not other greenhouse gas savings. This study ultimately might be an underestimate of CO₂ emissions avoided during a similar period, as the UNC health system had decreased numbers of appointments at the beginning of the pandemic. This study focused specifically on the impact on the patients’ carbon emission and did not consider the clinicians’ carbon footprint. Subsequent studies would be wise to estimate the clinicians’ impact, as some worked from home which increased their use of computers, monitors, or server spaces for hosting video visits.

The advantages and disadvantages of pivoting to virtual care were not evaluated by this study, yet these results suggest that continued utilization of telehealth could meaningfully contribute to mitigation of greenhouse gas emissions due to transportation [17]. It should be noted that the percentage of virtual behavioral health visits in our health system during the study period was quite high (85%), which fits with national trends during the period. However, with the overall return to in person health care, it is expected that the percentage of telehealth visits for behavioral health will also decline. Still, it is estimated that a significant portion of patients will continue to receive their behavioral health care via telehealth as the pandemic subsides [18]. Thus, it is anticipated that continued use of telehealth to conduct behavioral health care will be a feasible and significant way to contribute to a reduction in greenhouse gas emissions. Based on our results, we encourage organizational leaders in behavioral health and other medical fields to consider these benefits to society when making decisions regarding development and continued support of telehealth.

![Figure 1](https://example.com/fig1.png)

**Fig. 1** Number of visits and CO₂ from transportation saved over time. Data are plotted as weekly totals of visits and CO₂ saved due to reduced travel by patients using virtual visits.
Declarations

Ethics Declaration None; IRB-approved project.

Disclosures On behalf of all authors, the corresponding author states that there is no conflict of interest.

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