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International transport-related carbon footprint and traveler's profile in a travel clinic before and after COVID-19

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ABSTRACT

The carbon footprint of the tourism sector represents around 8% of global emission, almost half of which are linked to transport. COVID-19 has had a strong impact on international travel. During the pandemic, the desirability of a profound change in society has been at the center of debates. Indeed, while the COVID-19 pandemic brought travel and tourism to a halt, it might also have acted as a catalyst and accelerated trends toward more sustainable tourism. Therefore, the question of the influence of the pandemic on behavioral developments related to travel arises. The objective of this study is to describe the effects of the pandemic on travel by comparing pre- and post-pandemic data from a travel clinic. In our clinic, the proportion of tourists among travelers remained similar before and after the pandemic. After the pandemic, people traveled for significantly shorter periods. The carbon footprint of passenger international transport remains > 2.5 tons of CO_2-eq after COVID-19. As a result, practices are almost back to pre-pandemic levels. It would be interesting to follow the evolution of the phenomenon over time, by looking at the travel modalities (accommodation, food, local activities) and the ecological sensitivity of travelers.

Keywords: carbon footprint, travel clinic, COVID-19

INTRODUCTION

Climate change and its consequences for human health can no longer be seen as a hypothetical future. The latest report from the Intergovernmental Panel on Climate Change (IPCC) [1] emphasizes the urgent need to take action to reduce greenhouse gas emissions. Tourism is one of the sectors to be reformed, its carbon footprint represents around 8% of global emissions [2], almost half of those are linked to transport. COVID-19 has profoundly affected travel possibilities. International travel has fallen by 87% in 2020 according to the World Tourism Organization (UNWTO) [3]. During the pandemic, the desirability of societal change was at the center of the debate.

The resumption of travel is confirmed on a global scale by UNWTO. At the end of 2024, international tourism stood at 99% of the pre-pandemic level. The pandemic has helped highlighting the known link between the destruction of nature and the threat to human health. 60% of emerging infectious diseases (Zika, Ebola, Nipah, etc.) and almost all known pandemics (e.g., flu, HIV, and COVID-19) originate from zoonoses, i.e., diseases caused by infections of animal origin [4]. The underlying causes of pandemics like COVID-19 are the same as those that destroy biodiversity and disrupt the climate. The role of hypermobility in triggering the COVID-19 pandemic is well documented [5]. Global travel has evolved with ever increase speed, distance, and volume allowing a growing number of humans to interact with and introduce pathogens into new locations and populations. Air transportation is a vehicle for the rapid spread and dissemination of communicable diseases. The increased numbers of travelers and their spatial mobility have dramatically reduced geographic barriers for microbes and heightened the potential for spread of infectious diseases. To reduce the risk and prepare for future pandemics sustained, large-scale behavior changes through behavioral, environmental, social and systemic interventions [6].

Data exists supporting the fact that travelers concerned about environmental issues agree to pay more for less environmental impact [7]. The emergence of flight-shame (flyggskam) as a societal phenomenon predates COVID-19. This term refers to an individual's discomfort over flying because of its impact on climate change. But the willingness to adopt more sustainable travel behavior expressed by travelers does not always materialize.

The COVID-19 pandemic, however, has created an unprecedented situation within the tourism sector having the impact of the 2008 financial crisis 5 times [8]. Limited mobility, amongst other restrictions, has led to a series of temporary positive impacts such as improved air quality, and global CO_2 emissions are estimated to have dropped by 7% compared to 2019 levels [9]. While the COVID-19 pandemic brought travel and tourism to a halt, it might also have acted as a catalyst and

Table 1. Demographics of travelers

	2019	2022	2023	p-value			
				Global	2022 vs. 2019	2023 vs. 2019	2023 vs. 2022
Number of travelers (N)	9,200	5,993	7,610				
Age (median [IQR])	31.1 years [22.5, 46.7]	31.9 years [23.5, 46.9]	32.4 years [23.9, 48.3]	< 0.001	0.030	< 0.001	0.030
Age category (n, %)							
0-18	1,505 (16.4)	923 (15.4)	1,119 (14.7)				
18-45	5,196 (56.5)	3,426 (57.2)	4,241 (55.7)				
45-60	1,680 (18.3)	1,095 (18.3)	1,466 (19.3)				
60-inf	819 (8.9)	549 (9.2)	784 (10.3)				
Women (n, %)	4,966 (54.0)	3,202 (53.4)	4,094 (53.8)	0.800			

accelerated trends toward more sustainable tourism. The question of the influence of the pandemic on these behavioral developments arises. Between aspiration for change, ecological awareness and resumption of activities, the change in travel habits and traveler profiles seems interesting to study.

The objective of this study is to evaluate the effects of the COVID-19 pandemic on travel behavior by comparing pre-(2019) and post-pandemic (2022 and 2023) data from a travel medicine center.

MATERIALS AND METHODS

Data Collection

The study was conducted within the Center for Primary Care and Public Health (Unisanté), University of Lausanne by the tropical medicine, travel and vaccinations unit.

This center offers specialized consultations to international travelers. Data collected routinely in an electronic medical record (DIAMM), were collected prospectively from the files of all participants following the pre-travel consultations and analyzed retrospectively.

Travels of people who consulted the travel medicine center from January 1, 2019, to December 31, 2019, and from January 1, 2022, to December 31, 2023, were included in the analysis.

Demographic data extracted included age and gender. During each consultation, travelers provided information on their destination, length of trip, itinerary, reason for travel (visiting family or friends, business trip, tourism, humanitarian, or pilgrimage).

For each trip, the distance traveled was calculated by considering Geneva as the departure airport and the international airport of the capital of the country(ies) visited as the arrival airport.

The carbon footprint of each trip was calculated via the *MyClimate* online platform. In the absence of information on this subject, economy class travel was considered for all travelers. For trips to multiple destinations, the calculation followed the order specified by the traveler and noted by the consultant.

From May 1st to 15, 2023, 3 questions were added to the questionnaire completed by travelers during the consultation: “Should our clinic provide information on measures that can reduce the ecological footprint linked to travel? Have you taken the ecological footprint more into account when organizing your post-pandemic trips? Since the COVID-19 pandemic, have you reduced your air travel?”

Data Analysis

The overall analysis comparing the three years was performed using a Kruskal-Wallis test for continuous variables and a Chi-square test for categorical variables. In the case of differences in the overall analysis, a comparison by pair of years was carried out using a non-parametric Mann-Whitney test for continuous variables and using a Chi-square test for categorical variables.

A correction for multiple testing according to the Holm method was used in the comparisons by pairs of years. Data processing was carried out in Microsoft Office Excel and statistical analysis in R software version 4.3.2 [10].

RESULTS

Travel Demographics

9,200, 5,993, and 7,610 trips were included in 2019, 2022, and 2023, respectively (**Table 1**). The ages of travelers were between 2 months and 89 years in 2019, 54 days and 91 years in 2022 and 1 month and 87 years in 2023. Median ages (31 or 32 years), proportion of travelers between 18 and 45 years (56% or 57%), and the proportion of women (53% or 54%) among travelers were similar in 2019, 2022 and 2023.

Travel Characteristics

Destinations

The five most visited countries in 2019 were Tanzania (10%), Brazil (10%), Thailand (6%), Peru (6%), and Indonesia (6%) (**Table 2**). In 2022, the most visited countries were Tanzania (17%), Senegal (7%), Brazil (6%), Thailand (5%), and Colombia (5%). In 2023, the most visited destinations were still Tanzania (15%), Thailand (8%), Indonesia (7%), Brazil (7%), and Kenya (6%).

Purpose of the trip

In 2019, 77% of travelers were tourists, whereas this figure dropped to only 73% in 2022 ($p < 0.001$) (**Table 2**). This proportion increased again to 79% in 2023. The proportion of business or study-related travelers is very slightly lower in 2023 (11% in 2019 and 2022, 10% in 2023, $p = 0.007$). The proportion of VFR increased slightly in 2022, from 14% in 2019 to 17% in 2022 ($p < 0.001$), before returning to 13% in 2023. Although this only concerns a small number of individuals, pilgrimage trips have also decreased (0.4% of trips in 2022 and 2023 compared to 1.1% in 2019, $p < 0.001$).

Table 2. Travels' characteristics

	2019	2022	2023	p-value			
				Global	2022 vs. 2019	2023 vs. 2019	2023 vs. 2022
Number of continents visited (n, %)				0.005	0.100	0.004	0.200
1	8,818 (96.0)	5,737 (96.1)	7,270 (95.5)				
2	305 (3.3)	175 (2.9)	249 (3.3)				
> 2	61 (0.7)	57 (1.0)	91 (1.2)				
Length of stay (median [IQR])	20 days [13, 35]	16 days [12, 28]	16 days [13, 25]				
Travel duration category (n, %)				< 0.001	< 0.001	< 0.001	0.002
0-15 days	3,425 (37.4)	2,867 (48.1)	3,668 (48.4)				
15-30 days	3,047 (33.3)	1,762 (29.6)	2,357 (31.1)				
30-90 days	1,953 (21.3)	770 (12.9)	821 (10.8)				
90-180 days	351 (3.8)	239 (4.0)	337 (4.5)				
> 180 days	381 (4.2)	318 (5.3)	388 (5.1)				
Reason for travel (n, %)							
Tourism	6,309 (77.1)	4,060 (73.4)	5,596 (78.9)	< 0.001	< 0.001		< 0.001
Professional/studies	929 (11.4)	610 (11.0)	696 (9.8)	0.007	0.600	0.007	0.060
Visit to individuals	1,136 (13.9)	921 (16.6)	938 (13.2)	< 0.001	< 0.001		< 0.001
Humanitarian	390 (4.8)	225 (4.1)	255 (3.6)	0.001	0.100	0.001	0.200
Resident	74 (0.9)	34 (0.6)	47 (0.7)	0.090			
Mecca: Pilgrims/ seasonal workers	92 (1.1)	22 (0.4)	29 (0.4)	< 0.001	< 0.001	< 0.001	1.000

Table 3. Carbon footprint and kilometers traveled/by traveler

	2019	2022	2023	p-value			
				Global	2022 vs. 2019	2023 vs. 2019	2023 vs. 2022
Emissions per trip (median [IQR])	2.0 t-CO_2eq [2.0, 3.2]	2.6 t-CO_2eq [2.0, 3.0]	2.8 t-CO_2eq [2.0, 3.2]	< 0.001	< 0.001	0.030	< 0.001
Distance traveled per trip (median [IQR])	17,000 km [12,400, 19,200]	15,200 km [12,000, 18,200]	16,600 km [12,400, 19,200]	< 0.001	< 0.001	0.050	< 0.001
Total emissions	26'100 t-CO_2eq	16'400 t-CO_2eq	21'600 t-CO_2eq				
Total distance traveled	156 millions km	97 millions km	128 millions km				

Duration of the trip

48% of travelers traveled less than 15 days in 2022 and 2023 compared to 37% in 2019 (**Table 2**). The median length of stay decreased from 20 days in 2019 to 16 days in 2022 and 2023.

Distance Traveled and Carbon Footprint of Journeys

The median distance traveled per trip was significantly lower in 2022 compared to 2019 and 2023: 15,200 km in 2022 compared to 17,000 km in 2019 ($p < 0.001$) and 16,600 km in 2023 ($p < 0.001$) (**Table 3**).

The carbon footprint linked to international transport per journey was therefore slightly lower in 2022 (2.6 tons of CO_2 equivalents [t-CO_2eq]) compared to 2019 and 2023 (2.80 t-CO_2eq).

The cumulative carbon footprint linked to international transport of travelers who consulted our clinic was 26,100, 16,400, and 21,600 t-CO_2eq in 2019, 2022, and 2023, respectively. The average carbon footprint per traveler was 2.8 t-CO_2eq in 2019, 2,59 t-CO_2eq in 2022, and 2.8 t-CO_2e in 2023.

Traveler Behaviors and Motivations

272 travelers answered the questionnaire. 116 (43%) answered that they would like to receive information on measures that could reduce the carbon footprint of their trip; 85 (31%) that they take this carbon footprint more into account when organizing their trips and 130 (48%) that they have reduced their air travel.

DISCUSSION

Travel patterns in the study population demonstrate significant stability before and after COVID-19. Demographically, populations are similar across time. Most of the travelers are tourists, with a proportion remaining stable above 70%. A slightly higher proportion of VFR is noted in 2022, probably linked to a rebound effect, following several years of interruption of visits to their country of origin for people with family abroad. The most frequently found destinations also remain approximately the same.

Despite the emphasis on decline opportunities in the tourism sector [11, 12], in our study, more than 70% of travelers were tourists before and after the pandemic. Travelers do not seem ready to give up flying for leisure. A study, conducted among urban residents in Iceland, explored how city dwellers justify their international air travel [13]. The geography of this country makes it an interesting case study because it is a country in which to forgo flying is akin to giving up travel. In this study, even those very aware of ecological issues were not ready to quit flying and few were open to change. The justifications to continue flying differ depending on climate awareness level. A lack of alternative transport modes contributed to the vast behavior gap. Emphasis was placed on the benefits of travel, potentially due to harsh local weather.

Median distances traveled remained large in 2022, however travelers seem to be going a little less far. This reduction in distances travel has not been sustained over time. In 2023

travelers traveled the same distance as in 2019. In a questionnaire questioning 29,000 travelers in 30 countries, 61% declared a desire to travel in a more sustainable way [14]. Of the 272 travelers who answered the questionnaire in our study, half of them reported that they had reduced their air travel. According to a study carried out in Great Britain, which assessed the willingness of people to reduce their air travel beyond the COVID-19 period, 20 to 26% of the reduction in air transport could possibly be maintained in the long term (i.e., an annual reduction in emissions of 215 to 359 kg CO_2 per air traveler) [15]. People with the highest incomes travel more; however there was little difference in the relative voluntary reduction reported by income level. Renouncing the plane would therefore seem proportionate to the use made of it.

In our study, travelers also leave for less time. Leaving for shorter periods could be the expression of a form of "revenge travel". This terminology emerged in the United States during 2020 to describe the need to catch up trips that could not be made during the pandemic. This need, fueled by the lifting of restrictions [16], finds its origin in significant individual and collective tension linked to the constraints experienced during the pandemic. The lifting of restrictions associated with the reduction in tensions around the pandemic and the savings made during this period of forced restrictions associated with the fear of a potential next pandemic or future deprivations have fueled the phenomena [17].

The cumulative distance traveled was 155 million kilometers (equaling the distance between the earth and the sun) in 2019, 97 million kilometers in 2022 and 128 million kilometers in 2023. Reflecting the shorter distances traveled, the mean carbon footprint per traveler linked to transport is significantly lower in 2022 than in 2019. In 2023 we note a return to the pre-pandemic level. Over the 3 years studied, this footprint, however, remains high and exceeds 2 t-CO_2e per trip (for international transport alone). This threshold of 2 t-CO_2e corresponds to the average annual objectives for total emissions per person defined on a global scale by the IPCC to keep global warming below the threshold of 1.5 °C by 2050. However, people who consult the travel clinic do so because they travel in a tropical environment, which overestimates emissions linked to flying compared to the entire Swiss population. Before the pandemic, a Swiss person traveled on average around 9,000 km per year by plane [18], which represented around 10% of the country's CO_2 emissions. . The total carbon emissions related to international transport in our clinic represented 26,100 t-CO_2eq in 2019 (equaling 5.4% of total territorial emissions of of the city of Lausanne (482,633 t-CO_2eq in 2019, 3.3 t-CO_2eq per inhabitant) [19].In 2023, 89% of Swiss permanent resident population have undertaken at least one trip with overnight stays [20]. Most of them travelled outside of Switzerland, predominantly to neighboring European countries (Italy, Germany, and France). 15.2 million international trips were recorded among the Swiss population, even exceeding the pre-pandemic level.

In our population, there is no modification over time of the percentage of travelers travelling for business, despite the large theoretical potential for emissions reduction in this population. The pandemic has provided an opportunity to re-evaluate working practices and the management of business relationships, and business travel in particular. Critics of the emissions associated with hypermobile lifestyles is increasing as part of the global climate debate [21, 22] and the need to physically travel for business is increasingly being challenged [12]. Recent findings indicate that a significant 85% of global companies lack ambitious goals for reducing emissions from corporate travel [23].

Positive effects of travel experiences on perceived health and wellness have been demonstrated by multiple studies. These benefits have been found to gradually diminish after a vacation [24]. The benefit of travel for mental health has also been documented. A study provides evidence on the importance of being able to travel for social participation and self-rated health [25]. Constraints to travel outside the local area (> 15 miles from home, or 24 km) are related to poorer self-rated health, both via reduced social participation and other, unspecified paths. Thus, the benefits of travel are quite well established but, at the same time, travel industry is responsible for a significant share of global greenhouse gas emissions. The effects of global warming on human health, its disproportionate effects on vulnerable people, and the contribution of global travel to this issue cannot be overlooked. Changing climate conditions lead to more frequent and intense heatwaves, alters disease transmission patterns making pandemics more likely. Zoonotic diseases, food-, water-, and vector-borne illnesses become more prevalent. Extreme weather events like floods, droughts, wildfires, and windstorms exacerbate health risks. Altered weather patterns affect food and water availability leading to malnutrition, waterborne illnesses [26]. The stress and anxiety caused by climate-related disasters impact mental health [27]. The health and economic crisis resulting from COVID-19 underscores the risks of disregarding the importance of the link between human health and the state of the environment [28]. Promoting regional travel would probably be the best path to associate the benefits of travel with the urgency to reduce global emissions. Changing destination or transport mode could reduce the climate impacts from tourism transport without compromising people's experiences.

Our study has several limitations. This is a descriptive study which focuses on the international carbon footprint of transport without considering the rest of the elements linked to travel in a selected population who consult a specialized center. It would be interesting to follow the evolution of the phenomenon over time, by focusing more precisely on travel arrangements and broadening the analysis beyond transport. In order to shed better light on this issue, looking more closely at the frequency and motivations of travelers seems to be important.

CONCLUSION

Travel arrangements among the population who consulted our center show a return to the situation before the COVID-19 pandemic. Tourists still represented most of the travelers. No major changes were identified in travels patterns. Our results seem to show that travelers leave for a little less time but with a carbon footprint linked to the trip that remains considerable (equivalent to the total annual balance per person targeted by the IPCC). Regional travel would probably be the best path to associate the benefits of travel with the urgency to reduce global emissions.

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Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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