Title

Reducing the Environmental Impact of Health Care Conferences: A Study of Emissions and Practical Solutions.

Authors

Demeulenaere, Sasha
Drew, Taylor
Conway, Alexandra
et al.

Publication Date

2024-02-01

DOI

10.1200/GO.23.00209

Reducing the Environmental Impact of Health Care Conferences: A Study of Emissions and Practical Solutions

Katie E. Lichter, MD, MPH[1]; Ali Sabbagh, MD[1]; Sasha Demeulenaere, BS[2]; Taylor Drew, BA[2]; Alexandra Conway, BA[3]; Leticia Nogueira, PhD, MPH[4]; Gita Suneja, MD, MS[5]; Kelsey Kirkwood, MPH[6]; Karly Hampshire, MD[7]; Katherine Gundling, MD[1]; Arianne Teherani, PhD[1]; Sapna E. Thottathil, PhD[1]; and Osama Mohamad, MD, PhD[8]

DOI https://doi.org/10.1200/GO.23.00209

ABSTRACT

PURPOSE We aimed to examine the impact of different conference formats (in-person, virtual, and hybrid) of the ASCO conference on greenhouse gas (GHG) emissions and to recommend sustainable options for future conferences.

MATERIALS AND METHODS This study used data on the number of attendees, their departure locations, and the type of attendance (in-person *v* virtual) provided by ASCO between 2019 and 2022. The GHG emissions resulting from air and ground travel, remote connectivity, conference space utilization, hotel stays, distributed conference materials, and electricity use were estimated for each year. Emissions were stratified by attendee country of origin, type of attendance, and year. Simulations were conducted to evaluate how changes in conference size, location, and format impact emissions, as well as estimate the resulting mitigations from adopting the proposed changes.

RESULTS The highest estimated GHG emissions, calculated in carbon dioxide equivalents (CO_2e), were associated with the 2019 in-person conference (37,251 metric tons of CO_2e). Although international attendees had the largest contribution to emissions in all years (>50%), location optimization models, which selected conference locations that most minimized GHG emissions, yielded only minimal reductions (approximately 3%). Simulations examining changes to the conference format, location, and attendance percentage suggested that hub-and-spoke, where multiple conference locations are selected by global region, or hybrid models, with both in-person and virtual components, are likely to cause the largest drops in emissions (up to 86%).

CONCLUSION Using historical conference data, this study identifies key aspects that can be modified to reduce emissions and consequently promote more sustainable and equitable conference attendance. Hybrid conferences may be the best solution to maintain the networking opportunities provided by conferences while balancing out their environmental footprint.

ACCOMPANYING CONTENT

Data Supplement

Accepted December 11, 2023
Published February 15, 2024

JCO Global Oncol 10:e2300209

INTRODUCTION

The current climate crisis poses an immediate and significant threat to human health, largely due to the release of greenhouse gas (GHG) emissions from human activities.[1,2] Many industries, including health care and academia, are seeking innovative ways to reduce their climate impact. As air travel is the largest contributor to global GHG emissions from the transportation sector,[2] reducing emissions from professional activities such as conference travel is critical. In fact, conference travel can account for up to 35% of a researcher's total carbon footprint, and a single conference can contribute up to 7% of a scientist's annual GHG emissions.[3] Therefore, mitigating emissions from conferences at personal, institutional, and national levels is a crucial step for health care providers and the scientific community to prevent exacerbating poor patient and planetary health outcomes.

The ASCO conference is a prominent event in the health care field held each year in Chicago, Illinois, attracting a large and diverse audience. In-person attendance at the 2019 conference drew over 33,000 attendees, whereas virtual attendance surged in 2020 and 2021, with over 41,000 and nearly 30,000 participants, respectively. In 2022, ASCO hosted a hybrid conference with both virtual and in-person attendance with nearly 45,000 attendees, 24,000 in-person and 10,000 virtual. Virtual conferencing has been shown to significantly reduce GHG emissions because of restricted participant travel,

CONTEXT

Key Objective
What is the amount of carbon emissions associated with different conference attendance formats, and are there effective solutions to mitigate these emissions?

Knowledge Generated
In-person attendance has the highest associated amount of greenhouse gas emissions. Simulations conducted show that hub-and-spoke and hybrid attendance models can lead to considerable drops in emissions while maintaining the advantages of conference attendance and engagement.

Relevance
Our findings can be used by conference organizers and policymakers to plan inclusive and equitable conferences using an environmentally conscious approach.

increase diversity among attendees, and reduce barriers to attendance, such as time, health, or financial constraints.[4-6]

Previous studies have focused on emissions caused by in-person conference-related travel and extrapolated potential benefits to virtual conferences[7-9]; however, there are limited quantitative assessments of the largest contributors of conference-related emissions and propose targeted and sustainable alternatives.[10-12] Using attendance data from 2019 to 2022 ASCO conferences, this study addresses these gaps by conducting a quantitative analysis into the largest contributors of conference-related emissions, as well as present potential GHG emissions reductions associated with alternative, more sustainable models.

MATERIALS AND METHODS

Travel Distance Calculations

Data on the origin of US conference attendees by zip code, origin of international attendees by country, and participation format (in-person or virtual) from 2019 to 2022 were provided by ASCO staff. In accordance with the Common Rule, informed consent and study approval were not required since the data were deidentified.

For in-person attendance in 2019 and 2022, the conference was hosted in Chicago, Illinois. US attendees were matched to their nearest major airports using factors such as airport size, annual enplanements, and distance from the attendee's zip codes. Zip codes were validated and linked to their centroid location using 2021 zip code tabulation area data.[13] We excluded US participants with zip codes that did not match the centroid data from the analysis (n = 3,288, <2%). We used spatial data from the US Department of Transportation together and passenger data from the Federal Aviation Administration to identify 240 US airports with ≥100,000 enplanements in 2019.[14-16] We conducted a spatial join between zip code centroids represented in the ASCO attendee data and the 240 airports identified using ArcGIS Pro. We used Euclidean geometry to determine the airports that minimized the distance to each attendee's registered zip code.

For international attendees, we assumed they traveled from either a medium or large airport with the shortest total distance to all other airports in their country of origin and did not participate in the virtual component. Participants from countries with no medium or large airports were assumed to travel from small airports. Airport information by country was obtained using data from The World Bank Data Catalog.[17] We excluded international participants from countries that lacked International Organization for Standardization-3,166 country codes, which were used to map ASCO data and airport database data (n = 3, <1%).

The distances between the matched airports of origin and Chicago O'Hare International Airport (ORD) were calculated using the Vincenty (ellipsoid) method.[18,19] ORD was chosen as the assumed airport as it is the primary international hub for Chicago. The coordinates for all airports were obtained using an online database.[20]

Emission Calculations

To estimate travel-related emissions, we made the following assumptions. Participants traveling <300 miles to the conference were assumed to have driven there.[21,22] Although the ASCO conference runs for 10 hours per day for 5 days, attendees were assumed to attend the conference for 6 hours per day for 3 days. Participants traveling 40 miles or more stayed at a four-star hotel within walking distance. An additional 100 miles of driving to and from airports was assumed for attendees using air travel.[6,21,22] We estimated GHG emissions in units of carbon dioxide equivalents (CO_2e) for each in-person attendee, including emissions from travel, conference space, hotel stay, electricity, gas, and materials. CO_2e travel consumption was estimated using the Environmental Protection Agency GHG Tools and the Department of Transportation Bureau of

Transportation Statistics.[23,24] CO_2e consumption for hotel stay and conference space utilization (including electricity, gas, and materials) was estimated using the Hotel Footprinting Tool and MyClimate Carbon Offset calculator.[25,26] We used the square footage of McCormick Place, the convention center in central Chicago where the ASCO is hosted, to estimate total space utilization in this calculation. We did not include food, food waste, local transportation, and other disposables in our calculations. For virtual attendees, emissions were estimated on the basis of CO_2e from standard video platform use and associated electricity.[27]

Simulations

To estimate the potential benefit of different conference models on CO_2e emissions, we performed the simulations listed below. Note that simulations A, B, and C were specific to in-person conference formats and were only applied to data from 2019 to 2022. All simulations were calculated using R.

A. Removing Outliers

We estimated the decrease in total emissions associated with excluding travelers with extreme distances, defined as distances greater than two standard deviations from the average distance to the conference center.

B. Alternative Locations

This simulation estimated emissions associated with holding the conference at different locations, specifically Honolulu (Hawaii), Vienna (Austria), and New York City (New York), which tend to be popular oncology conference locations.

C. Minimizing Distances and Emissions

With flight-related emissions likely to make up a significant proportion of overall emissions, we conducted a simulation estimating the benefit of a conference model aimed at minimizing overall distance traveled and compared the results of this model to an optimal case scenario that minimizes overall emissions. Additionally, we performed an analysis where the conference location was selected to minimize CO_2e emissions from US participants only (first simulation) and from all participants (second simulation).

D. Hybrid Model

This simulation is intended to quantify the expected benefit of hybrid conferences using worst case and best case analyses, where attendees from locations with the lowest and highest emissions, respectively, are assumed to have attended virtually. This approach allows us to obtain a range of emissions reduction associated with conferences held in a hybrid format.

E. Hub-and-Spoke Models

In this simulation, we divided countries into six subregions: North America, Europe, the Middle East and Africa, Latin and South America, and the Caribbean, Asia, and Oceania. We selected a hub within each region. Attendees in countries (spokes) from that subregion were assumed to travel to the hub (also a country in the subregion) to attend the conference in-person. In the first simulation, we selected the country that minimized the distance traveled from all countries in the subregion as the hub. For the second simulation, we chose more realistic hub locations where conferences were more likely to be held (ie, locations that already host major conferences). For example, while Sudan is chosen as the hub for the Middle East and North Africa in the ideal scenario of the simulation because of it minimizing travel distance for attendees in the region, Egypt was selected as the hub in the realistic scenario of the simulation.

F. Turning Cameras Off

Research has demonstrated that turning cameras off in virtual sessions can significantly reduce CO_2e emissions, up to 96%.[27] Thus, we assumed that all attendees turned off their cameras and conducted the simulation, accordingly, resulting in emissions that were only 4% of standard virtual emissions.

Statistical Analysis

All calculations and simulations were performed using R statistical software (v.4.1.2, R Foundation, Vienna, Austria), and P values <.05 were considered statistically significant. The details on the assessment of statistical significance can be found in the Data Supplement.

RESULTS

Conference Emissions and Attendees

Attendance and emissions from 2019 through 2022 ASCO conferences are summarized in Table 1. CO_2e emissions were the highest in 2019 when attendance was fully in-person and the lowest in 2020 and 2021 when the conference was fully virtual. The total CO_2e emissions for the 2019 in-person conference were 37,251.45 metric tons, which is equivalent to the annual emissions of 8,018 gasoline-powered passenger vehicles. This estimation assumes that an average US vehicle travels 11,500 miles per year with a fuel economy of 22.0 miles per gallon.[23] Using the 2019 attendance data, we further stratified average emission contributions per person by travel, conference space utilization, and hotel stay (Fig 1). As expected, travel accounted for the majority of emissions per person (81.3%). By contrast, the average CO_2e emissions for the virtual conference format were 99.17 metric tons, equivalent to the annual emissions of 21.4 gasoline-powered

TABLE 1. Attendance and Emissions of the ASCO Conferences Between 2019 and 2022

Attendance and Emission	Y2019	Y2020	Y2021	Y2022
Attendance				
Total No. of attendees (No.)	33,562	41,199	29,634	35,133
Total No. of omitted attendees (No.)	829	1,070	556	833
No. of in-person attendees, percentage out of total, No. (%)	33,562 (100.00)	0 (0.00)	0 (0.00)	24,360 (69.34)
No. of virtual attendees, percentage out of total, No. (%)	0 (0.00)	41,199 (100.00)	29,634 (100.00)	10,773 (30.66)
No. of US in-person attendees, percentage out of total, No. (%)	18,731 (55.81)	0 (0.00)	0 (0.00)	17,295 (49.23)
No. of US virtual attendees, percentage out of total, No. (%)	0 (0.00)	19,241 (46.70)	13,597 (45.88)	3,594 (10.23)
No. of international in-person attendees, percentage out of total, No. (%)	14,831 (44.19)	0 (0.00)	0 (0.00)	7,065 (20.11)
No. of international virtual attendees, percentage out of total, No. (%)	0 (0.00)	21,958 (53.30)	16,037 (54.12)	7,179 (20.43)
No. of percentage of attendees traveling <300 miles, No. (%)	2,330 (6.94)	0 (0.00)	0 (0.00)	2,126 (6.05)
No. of percentage of attendees traveling 300-3,000 miles, No. (%)	17,767 (52.94)	0 (0.00)	0 (0.00)	16,161 (46.00)
No. of percentage of attendees traveling >3,000 miles, No. (%)	13,465 (40.12)	0 (0.00)	0 (0.00)	6,073 (17.29)
Emissions				
Total CO_2e emissions (metric tons, t)	37,251.45	115.36	82.98	20,190.01
Total CO_2e emissions (t) ppa	1.11	0.0030	0.0030	0.58
Total CO_2e emissions (t) from in-person attendance	37,251.45	0.00	0.00	20,159.84
Percentage CO_2e emissions (%) from in-person attendance	100.00	0.00	0.00	99.85
Total CO_2e emissions (t) from in-person attendance ppa	1.11	0.00	0.00	0.83
Total CO_2e emissions (t) from attendees traveling <300 miles	362.23	0.00	0.00	339.39
Percentage CO_2e emissions (%) from attendees traveling <300 miles	0.97	0.00	0.00	1.68
Total CO_2e emissions (t) from attendees traveling 300-3,000 miles	9,110.68	0.00	0.00	8,343.25
Percentage CO_2e emissions (%) from attendees traveling 300-3,000 miles	24.46	0.00	0.00	41.32
Total CO_2e emissions (t) from attendees traveling >3,000 miles	27,778.55	0.00	0.00	11,477.21
Percentage CO_2e emissions (%) from attendees traveling >3,000 miles	74.57	0.00	0.00	56.85
Total CO_2e emissions (t) from US attendees	8,657.95	53.87	38.07	8,076.1
Percentage CO_2e emissions (%) from US attendees	23.24	46.70	45.88	40.00
Total CO_2e emissions (t) from international attendees	28,593.51	61.48	44.9	12,113.90
Percentage CO_2e emissions (%) from international attendees	76.76	53.30	54.12	60.00
Total CO_2e emissions (t) from virtual attendance	0.00	115.36	82.98	30.16
Percentage CO_2e emissions (%) from virtual attendance	0.00	100.00	100.00	0.15
Total CO_2e emissions (t) from virtual attendance ppa	0.00	0.0027	0.0028	0.0028
Total CO_2e emissions greenhouse equivalence (gasoline-powered passenger vehicles driven for a year)	8,009.06	24.80	17.84	4,340.85
Total in-person attendance CO_2e emissions greenhouse equivalence	0.24	0.00	0.00	4,334.37
Total virtual attendance CO_2e emissions greenhouse equivalence	0.00	0.00060	0.00060	6.48

Abbreviations: CO_2e, carbon dioxide equivalents; ppa, per person average.

passenger vehicles. The 2022 hybrid conference resulted in 20,190 metric tons of CO_2e emissions, equivalent to the annual emissions of 4,351 gasoline-powered passenger vehicles. The adoption of a hybrid format led to a significant drop in emissions/per person compared with the 2019 conference ($P < .001$). The calculated average per-person CO_2e emissions for the in-person, virtual, and hybrid formats were 1.11, 0.0028 (difference with the emissions from the 2019 conference is 1.1071, $P < .001$, 95% CI (1.0979 to 1.1163), and 0.5747 metric tons (difference with the emissions from the 2019 conference is 0.5352, $P < .001$ [95% CI, 0.5236 to 0.5469]), respectively.

The implementation of the fully virtual format in 2020 resulted in a 22.75% increase in attendance compared with the 2019 in-person conference (Table 1). This trend did not continue in 2021, where attendance decreased compared with the 2019 conference. The 2021 conference, which was fully virtual, had the lowest emissions because of the conference modality and the lowest attendance of the 4 years. Furthermore, the percentage of international attendees was higher in 2020 and 2021, which is likely attributed to the convenience of virtual formatting. International attendees were the largest contributors to CO_2e emissions, regardless of whether the conference was in-person or virtual, with

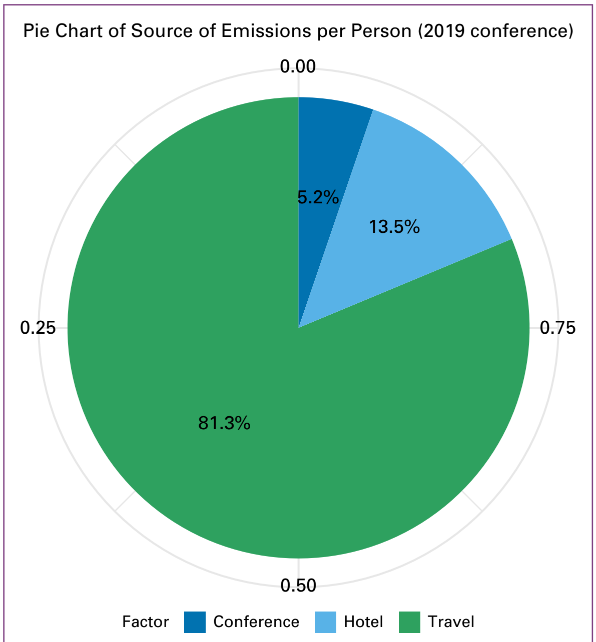


FIG 1. Pie chart of source of emissions per person (2019 conference).

international attendees accounting for more than 50% of total CO_2e emissions. Reduced emissions from international attendees were observed between 2019 and 2022, decreasing from approximately 29,000 to 12,000 metric tons of CO_2e. This is attributed to the adoption of a hybrid conference model and to travel restrictions that were imposed in response to the COVID-19 pandemic. Figure 2 illustrates the emissions per person from international attendees in 2019 and 2022. In 2022, emissions per person from most countries were found to be <800 metric tons of CO_2e, which is well below 2019 levels. Notably, the emissions from China were nearly nonexistent in 2022, which could be attributed to COVID-19–related travel restrictions.

Simulations

Table 2 summarizes the emissions of different simulations of the ASCO conferences between 2019 and 2022. Simulation A shows that removing attendees from outlier locations has a modest effect on overall emissions, with reductions in overall emissions of approximately 7% and 4% for the 2019 and 2022 conferences, respectively. Although this translates to a statistically significant difference in emissions per person ($P < .001$), this difference remains minimal at an estimated 5% (95% CI, 0.040 to 0.066) decrease for the 2019 conference.

The results of simulations B, C, and E show the contribution of conference location on overall emissions. Changing the location to other popular destinations (simulation B, Table 2 and Fig 3A) leads to considerable changes in emissions for the 2019 conference. Moving the conference to New York leads to approximately 2.8% decrease in overall emissions, whereas moving the conference to Vienna or Honolulu leads to approximately 44% and 80% increases, respectively. A similar trend is seen for the 2022 conference.

Simulation C shows the effect of a data-driven choice of the conference location. Selecting a conference center that minimizes distance traveled leads to an estimated approximately 0.77% drop in emissions. A more thorough analysis showed that the maximum drop in emissions that can be achieved on the basis of the choice of conference location alone amounts to approximately 2.99% reduction. The discrepancy between these two optimization scenarios is due to the contribution of the number of attendees to the calculation of emissions. While distance is an important factor, areas with a larger number of attendees can lead to higher total emissions than those with a lower number.

Simulation D (Table 2 and Fig 3B) highlights the potential reduction in emissions obtained by modifying the percentage of virtual attendance in a hybrid conference on the basis of the 2019 attendance mix. Even in the worst case, holding a conference with as little as 25% virtual attendance leads to approximately 13% drop in emissions for the 2019 conference. This reduction can go up to approximately 87% in the best case scenario, with 75% virtual attendance.

Simulation E shows the associated emissions reduction of a hub-and-spoke model, that is, having multiple conference locations with attendees allocated to their closest location (Table 2 and Fig 4). A hub-and-spoke model for the 2019 conference, for example, can reduce emissions by 54%-59%, on the basis of a choice of realistic and ideal locations, respectively.

DISCUSSION

Preventing irreversible climate change will require significant emission reduction across all sectors by 2030 and achieving net-zero emissions by 2050.[1,27,28] However, there has been little focus on addressing emissions from conference travel to meet these targets.[28-32] Our study shows that although international attendance makes up most conference-related emissions (>50%), international attendance need not be limited to mitigate emissions. In fact, our simulations show that considerable emissions reduction can be achieved by restructuring conference parameters. This is evident in simulation D, where some level of virtual attendance resulted in a considerable decrease in conference-related emissions. Virtual conferencing has been criticized for compromising networking, professional development, and social interaction. However, studies have shown that virtual conferencing can provide structured networking opportunities while achieving workshop objectives comparable with in-person formats.[33] Additionally, up to 60% of participants are willing to accept the downsides of virtual conferencing in exchange for personal and environmental benefits.[34] Previous qualitative assessments of virtual and hybrid professional development conferences have identified flexibility,

FIG 2. Emissions per person (in metric tons of CO_2e) from international attendance by country in (A) 2019 and (B) 2022 in person conferences, and tree maps showing emissions by country (in metric tons of CO_2e) for (A) 2019 and (B) 2022 conferences. CO_2e, carbon dioxide equivalents.

TABLE 2. Emissions of Difference Simulations of the ASCO Conferences Between 2019 and 2022

Simulation	Y2019	Y2020	Y2021	Y2022
Simulation A				
Total CO_2e emissions (t) after removing outliers	34,653.40	NA	NA	19,391.79
Simulation B				
Total CO_2e emissions (t) from in-person in Honolulu, Hawaii	66,899.56	NA	NA	46,307.28
Total CO_2e emissions (t) from in-person in Vienna, Austria	53,518.96	NA	NA	39,885.51
Total CO_2e emissions (t) from in-person in New York, New York	36,193.78	NA	NA	19,360.24
Simulation C				
Total CO_2e emissions (t) from in-person minimizing all attendee travel distances	36,963.04	NA	NA	NA
Total CO_2e emissions (t) from in-person minimizing US attendee travel distances	38,526.85	NA	NA	NA
Total CO_2e emissions (t) from in-person minimizing US attendee travel distances	91,25.90	NA	NA	NA
Total CO_2e emissions (t) from in-person minimizing US emissions	83,75.128	NA	NA	NA
Total CO_2e emissions (t) from in-person minimizing all attendee emissions	36,139.10	NA	NA	NA
Simulation D				
Total CO_2e emissions (t) from 100% in-person conference	37,251.45	51,658.41	36,260.08	36,544.18
Total CO_2e emissions (t) from hybrid model: 25% virtual, 75% in-person (bc)	21,110.96	30,301.95	22,330.98	21,296.61
Total CO_2e emissions (t) from hybrid model: 50% virtual, 50% in-person (bc)	12,716.86	18,402.30	12,353.89	13,523.34
Total CO_2e emissions (t) from hybrid model: 75% virtual, 25% in-person (bc)	5,001.55	6,884.66	5,045.32	5,143.58
Total CO_2e emissions (t) from hybrid model: 25% virtual, 75% in-person (wc)	32,342.02	44,887.42	31,295.59	31,498.60
Total CO_2e emissions (t) from hybrid model: 50% virtual, 50% in-person (wc)	24,628.56	33,369.84	23,989.16	23,118.82
Total CO_2e emissions (t) from hybrid model: 75% virtual, 25% in-person (wc)	16,233.69	21,470.19	14,009.96	15,344.22
Total CO_2e emissions (t) from 100% virtual conference	93.973	115.357	82.97	98.37
Simulation E				
Total CO_2e emissions (t) from ideal hub-and-spoke model (six locations)	16,958.76	21,731.68	15,557.15	12,171.32
Total CO_2e emissions (t) from realistic hub-and-spoke model (six locations)	15,142.64	19,433.25	14,248.91	16,549.01
Simulation F				
Total CO_2e emissions (t) from virtual attendance with all cameras turned off	3.76	4.61	3.319	1.21

Abbreviations: bc, best case; CO_2e, carbon dioxide equivalents; NA, not applicable; wc, worst case.

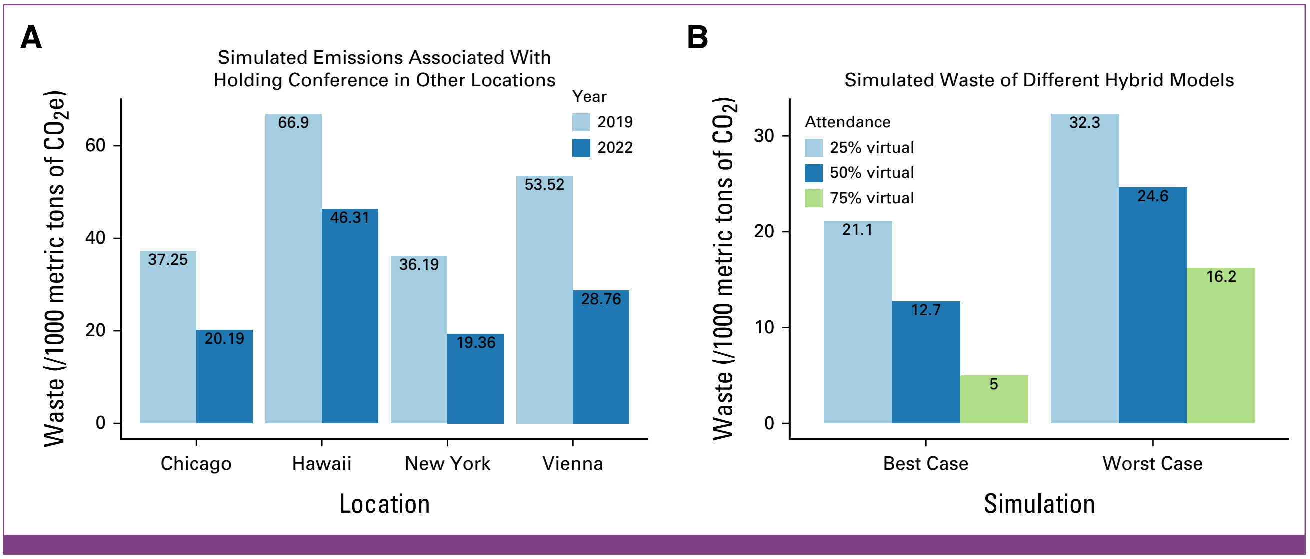


FIG 3. (A) Simulated emissions/person associated with holding the ASCO conference in alternative locations. (B) Graphs stratifying CO_2e emissions based on the percentage of in person versus virtual attendees. CO_2e, carbon dioxide equivalents.

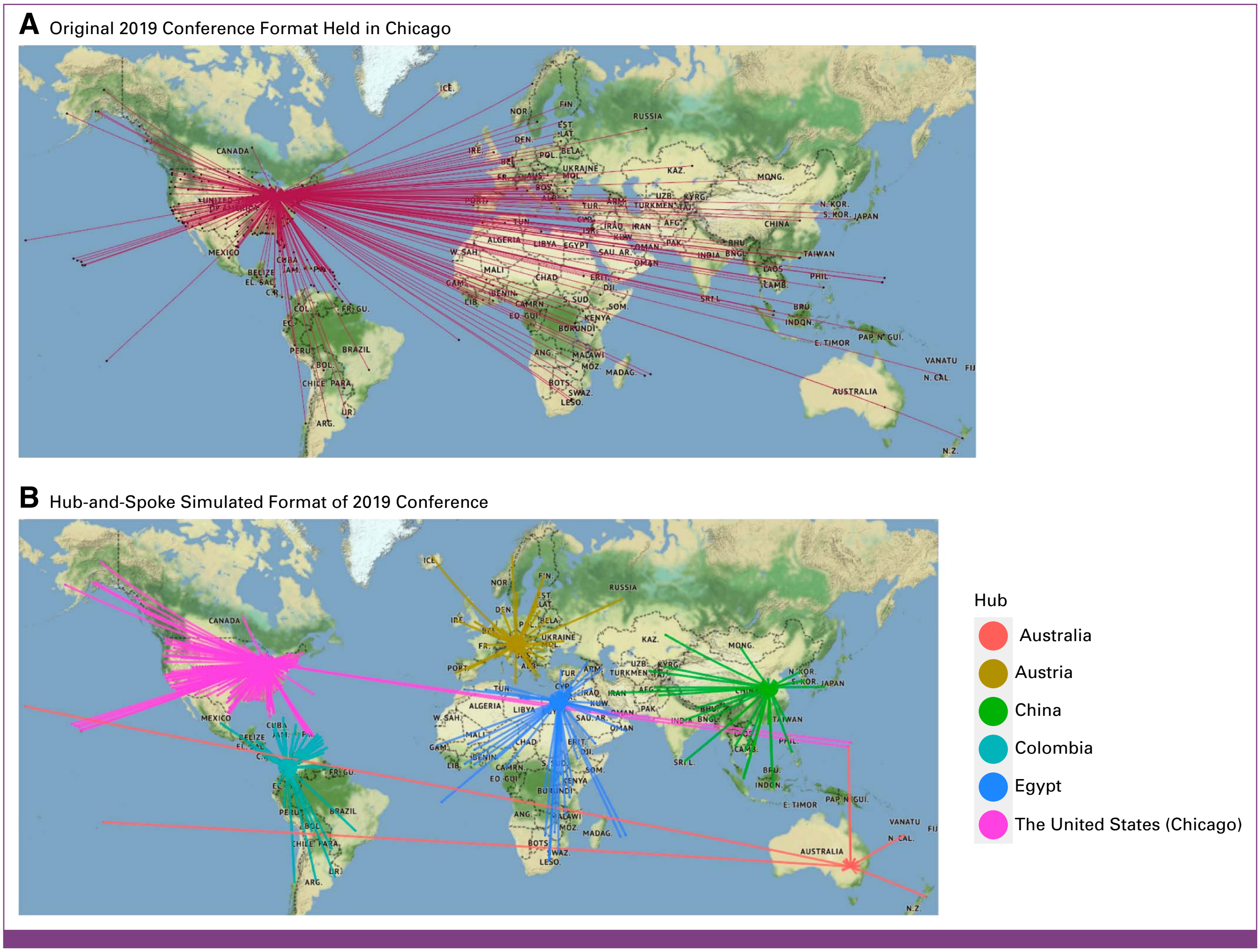


FIG 4. Travel patterns of participants attending the 2019 conference using (A) actual conference format and (B) hub-and-spoke format.

accessibility, and useful incorporation of technology as major assets of a virtual conference format that can help offset other downsides.[35] Hybrid or virtual formats also have the potential to improve diversity, equity, and inclusion within the medical field by removing financial, physical, and temporal barriers for individuals with disabilities, caretaking responsibilities, and financial constraints.[4,34] Although hybrid and virtual formats have already been successfully used in several fields, including surgery, dermatovenereology, and rheumatology, they have unexplored potential for further optimization and utilization.[36-38] It is important to consider digital inequalities and ensure that virtual conferencing opportunities are inclusive and accessible to all including those with limited access to technology, internet, and/or electricity.

An intuitive solution would be to minimize the distances traveled by participants. However, as seen in the results of our simulations, this had only a small effect on overall emissions. Interestingly, selecting a conference location that minimizes emissions, even when in possession of full attendance information, leads to a minimal decrease (approximately 2.99%). This reduction floor can be overcome using a hub-and-spoke model. From our results, a hub-and-spoke model eliminates more than half of emissions while maintaining in-person attendance. However, although it successfully balances these desirable characteristics, it is not without drawbacks. A considerable proportion of health care research is published in the global north and such models might inadvertently exclude participants from the global south from important conversations and opportunities. Additionally, the extra planning required for multiple conference hubs may not be feasible for organizations at present; however, the utilization of novel technologies may soon mitigate this barrier. Successful hub-and-spoke conferences from other industries have used technology such as Mediasite, Barco, and Black Box, and growing interest in virtual conference alternatives will not only improve our current technology but drive further innovation.[39] Future investigations should explore the incorporation of incentives, such as reduced conference fees, extended speaking sessions, and enhanced networking opportunities for virtual attendees, as these measures can promote equity of access and make virtual participation more appealing, encouraging a wider and more inclusive engagement in sustainability initiatives.

A

COMMITMENT TO SUSTAINABILITY WHILE ATTENDING CONFERENCES

All conference attendees (whether participating in-person or virtual) can be leaders in their commitment to environmental sustainability and social responsibility.

IN-PERSON ATTENDANCE

Reducing Travel Emissions
- Find flights with lower carbon emissions.
- Consider alternative modes of transportation to the conference (i.e. train, public transport, carpooling).
- Utilize public transportation (if available) to travel from the airport to the hotel.
- Walk to-and-from conference activities whenever possible.

Minimizing Waste
- Use the appropriate onsite recycling bins to help reduce the waste sent to landfills.
- Bring your own reusable water bottle and/or coffee mug.
- Reuse towel in your hotel room.
- Prioritize digital rather than paper-based posters. If printed materials are needed, select more sustainable options (FSC certified paper, soy-based ink, double-sided printing, etc.)
- Distribute your presentation electronically.
- Consider digital alternatives to paper business cards.
- Choose sponsor gifts wisely. Take only what you will need and use.

Choosing Accommodations
- Consider booking accommodations at an eco-friendly venue (ask to see a venue's environmental policy).
- Select a venue that has good access to the conference via public transportation.

Eating Sustainably
- Opt for plant-forward conference meal options when given the choice. Limit consumption of animal products including red meat.
- Choose restaurants with meals that are locally sourced and plant forward where possible.

Making/Sharing Your Personal Commitment
- Share your conference sustainability successes and stories with other attendees and/or the conference hosts via social media.

VIRTUAL ATTENDANCE

Reduce Streaming Energy
- Turn off your video camera when appropriate.
- Dim computers and electronic screens.

Home Energy
- Minimize use of lighting, heating, and air conditioning. Choose rooms to stream from with windows that provide natural light and appropriate airflow.

Eating Sustainably
- Opt for plant-forward meals and snacks throughout the duration of the conference.
- Prepare meals and shopping in advance to avoid purchasing food delivery or take out.
- Limit all food waste.
- Practice sustainable purchasing procurement of food and beverages (i.e. local and organic suppliers).
- Continue diligent use of home composting/recycling. Utilize a conference break to stretch and take out your compost and recycle bins!

Making/Sharing Your Personal Commitment
- Share your conference sustainability successes and stories with other attendees and/or the conference hosts via social media

Lichter et al, GreenHealth Lab

FIG 5. (A) Commitment to Sustainability at Conferences for Individual Attendees and (B) Commitment to Sustainability at Conferences for Conference Organizers. Abbreviation: FSC, Forest Stewardship Council; HVAC, heating, ventilation, and air conditioning. (continued on following page)

B

COMMITMENT TO SUSTAINABILITY AT CONFERENCES

REDUCING THE ENVIRONMENTAL IMPACT OF IN-PERSON MEETINGS

All conferences and professional societies can be leaders in committing to hosting environmentally and socially responsible conferences.

Organizational Commitment

Consider implementing a sustainability lead or sub-committee within the conference management team to keep these commitments and goals front and center.

Communicate with registered attendees ahead of time about your sustainability efforts and establish a landing page on the conference website to communicate the commitment to sustainability.

Provide actionable ways attendees can help reduce the event's environmental footprint.

Set conference sustainability targets. Track, communicate, and celebrate your successes.

Work with an event planning partner that focuses on sustainable event planning (e.g. MeetGreen).

Waste Minimization and Diversion

Reduce paper use (minimize handouts) or select more sustainable options (FSC certified paper, soy-based ink, double-sided printing, etc.)

Use a digital app to replace agendas/programs and distribute presentations electronically.

Encourage participants use of digital business cards.

Ensure paper and cardboard recycling bins are available to divert waste from landfills.

Meeting Consumables

Prioritize digital over paper-based signage.

Select reusable name badges that can be collected at the end of an event and recycled/re-used.

Encourage vendors to keep promotional giveaways to a minimum, or encourage sustainable options.

Sustainable and Healthy Catering

Prioritize sustainable food and beverage procurement (i.e. local/organic suppliers, seasonal offerings, plant-based).

Optfor reusable or biodegradable cutlery and consider bulk food options (e.g. a carton of cream instead of individual creamer pods).

Consider making plant-forward food options the default and give attendees the choice to opt-in for meals with animal products.

Compost and/or donate excess food from meal events.

Avoid using plastic water bottles and paper cups and encourage attendees to use reusable water bottles and coffee cups.

Carbon Reduction

Minimize the use of lighting, heating, and air conditioning. Choose meeting rooms with windows that provide natural light where possible.

Actively promote the use of public transportation, bikes, and walking to off-site events.

City/Location Selection

If possible, select a centralized location that minimizes travel for most attendees and can be accessed via multi-occupant transportation (i.e. train, public transport, carpooling, etc.).

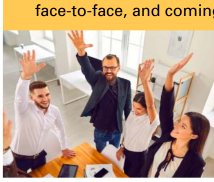
Venue Selection

Ask to see a venue's environmental policy and any appropriate certifications.

Select a venue with (or agreeable to) refillable water stations, energy-efficient lighting/HVAC systems, and water-conserving plumbing fixtures.

TRAVEL CONSIDERATIONS

The largest proportion of an event's associated emissions is travel, accounting for more than **90%** of emission for an average event. Yet, there is significant value in human interaction, gathering face-to-face, and coming together as a network.



Offer hybrid and virtual options for all attendees. This mutually increases accessibility and equitability of the event.

Alternate annual meetings between in-person and online events.

Host bi-annual in-person meetings versus annual meetings.

Establish decentralized hub-and-spoke models with multiple regional conference venues allowing for minimization of attendee travel.

Consider establishing a carbon offset partner with a designated funding project (ex: Carbonfund.org and the Capricorn Ridge 4 Wind Farm). Purchase offsets for the event and provide options for attendees to do the same.

Lichter et al, GreenHealth Lab

FIG 5. (Continued).

Conference organizers and attendees can also take immediate steps to incorporate environmental sustainability into their events. These steps can include reducing waste by swapping single-use materials for reusable or digital materials, implementing recycling and composting systems at all conferences, and using energy-efficient protocols.[40]

Providing environmentally responsible meal options, such as plant-based or locally sourced meals, and green transportation options can also help reduce emissions. Carbon offset programs can be used as an intermediary option until more robust and sustainable alternatives are available. By taking these actions, health care and academic conferences can lead by example in reducing GHG emissions and promoting sustainable practices. Figure 5 includes our previous work on impactful initiatives for conference organizers to significantly reduce emissions. Additionally, our GreenHealth Lab[41] is launching a calculator, Network Greener, which will allow individuals and conference organizations to calculate emissions associated with their conference plans and provide information on how to offset these with both lifestyle and systemic changes. This tool also allows attendees to appropriately weigh the advantages of attending in person with the GHG emissions associated with attendance.

Our study offers valuable insights into the GHG emissions associated with health care conferences, but it is important to acknowledge its limitations. First, participants may have been misclassified to the airport of origin from their institutional zip code, although we expected this to even out across the population and have a negligible impact. Second, our calculations assumed that participants would miss some conference programming and not attend all events, which may underestimate emissions as full conference attendance would result in higher emissions. Additionally, COVID-19–related travel restrictions may have confounded our results, particularly in the decreased emissions observed with the 2022 hybrid model. Finally, our study did not account for factors such as layovers, waste disposal, electrical grid efficiency, alternative transportation, and food, which may increase emissions. The decision to exclude these factors was based on limited scientific literature and verified metrics. Future studies that include these factors are essential to gain a more comprehensive understanding of conference-related emissions. For example, although we could not quantify the emissions of single-use conference materials because of variability in types, composition, and quantity, it is a known source of waste and emissions that could be targeted with further research. Despite these limitations, our study offers a novel perspective on conference-related emissions which has been lacking in previous literature because of survey selection bias, smaller data sets, or failure to consider hybrid formats and emissions from virtual participation.[42-46] By using actual data from the 2019 to 2022 ASCO conferences and modeling multiple alternative formats, including virtual format emissions, our study provides a pilot examination of conference-related emissions.

As health care providers, we bear a unique responsibility to reduce GHG emissions, especially considering the intrinsic emissions in health care activities that are difficult to minimize. Therefore, it is crucial to plan inclusive and equitable conferences that account for planetary harm. Our study provides quantitative evidence that virtual and hybrid conferencing significantly reduces GHG emissions, which can encourage more intentional and conscientious planning of future health care conferences. Utilization of environmentally conscious strategies can foster greater participant inclusion and reduce GHG emissions.

AFFILIATIONS

[1]University of California San Francisco, San Francisco, CA
[2]Stritch School of Medicine, Maywood, IL
[3]Geisel School of Medicine, Hanover, NH
[4]American Cancer Society, Kennesaw, GA
[5]University of Utah, Salt Lake City, UT
[6]American Society of Clinical Oncology, Alexandria, VA
[7]Columbia University, New York, NY
[8]MD Anderson Center, Houston, TX

CORRESPONDING AUTHOR

Katie E. Lichter, MD, MPH, Department of Radiation Oncology, University of California San Francisco, 1825 Fourth Street, San Francisco, CA 94158; e-mail: katie.lichter@ucsf.edu.

PRIOR PRESENTATION

Presented at American Society of Clinical Oncology, Chicago, IL, June 3-7, 2022; Sinai Climate Conference, New York, NY, June 6, 2023; and ASCO Quality Care Symposium, Boston, MA, October 27-28, 2023.

SUPPORT

Supported by San Francisco Bay Physicians for Social Responsibility Trainee Grant.

AUTHOR CONTRIBUTIONS

Conception and design: Katie E. Lichter, Sasha Demeulenaere, Taylor Drew, Alexandra Conway, Karly Hampshire, Katherine Gundling, Arianne Teherani, Osama Mohamad
Administrative support: Katie E. Lichter, Taylor Drew, Arianne Teherani, Osama Mohamad
Provision of study materials or patients: Osama Mohamad
Collection and assembly of data: Katie E. Lichter, Sasha Demeulenaere, Taylor Drew, Alexandra Conway, Kelsey Kirkwood, Osama Mohamad
Data analysis and interpretation: Ali Sabbagh, Sasha Demeulenaere, Alexandra Conway, Leticia Nogueira, Gita Suneja, Kelsey Kirkwood, Sapna E. Thottathil, Osama Mohamad
Manuscript writing: All authors
Final approval of manuscript: All authors
Accountable for all aspects of the work: All authors

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

The following represents disclosure information provided by authors of this manuscript. All relationships are considered compensated unless otherwise noted. Relationships are self-held unless noted. I = Immediate Family Member, Inst = My Institution. Relationships may not relate to the subject matter of this manuscript. For more information about ASCO's conflict of interest policy, please refer to www.asco.org/rwc or ascopubs.org/go/authors/author-center.

Open Payments is a public database containing information reported by companies about payments made to US-licensed physicians (Open Payments).

Osama Mohamad
Employment: MD Anderson Cancer Center
Research Funding: Salesforce

No other potential conflicts of interest were reported.

ACKNOWLEDGMENT

We thank Julie Lindow, Eric Bernicker, Jasmine Kamboj, and Chirjiv Anand for their support of this work.

REFERENCES

1. Pörtner H-O, Roberts DC: Climate Change 2022: Impacts, Adaptation and Vulnerability
2. Romanello M, Di Napoli C, Drummond P, et al: The 2022 report of the lancet countdown on health and climate change: Health at the mercy of fossil fuels. Lancet (London, England) 400:1619-1654, 2022
3. Achten WMJ, Almeida J, Muys B: Carbon footprint of science: More than flying. Ecol Indic 34:352-355, 2013
4. Bernard M: How Virtual Convenings Can Enhance Diversity, Equity, Inclusion, and Accessibility—NIH Extramural Nexus. 2022
5. Jain S, Graff SL, Swaroop M, et al: Support structures for female physicians: Motivations and barriers to gender-specific conferences and symposia. J Clin Oncol 37, 2019 (15_suppl; abstr 10518)
6. Lichter KE, Drew TE, Demeulenaere S, et al: Environmental outcomes associated with transition from in-person to a virtual oncology conference during the COVID-19 pandemic. JAMA Oncol 8: 1351-1352, 2022
7. Bousema T, Selvaraj P, Djimde AA, et al: Reducing the carbon footprint of academic conferences: The example of the American Society of Tropical Medicine and Hygiene. Am J Trop Med Hyg 103: 1758-1761, 2020
8. Jäckle S: The carbon footprint of travelling to international academic conferences and options to minimise it, in Bjørkdahl K, Franco Duharte AS (eds): Academic Flying and the Means of Communication. Singapore, Springer Nature Singapore, 2022, pp 19-52
9. Milford K, Rickard M, Chua M, et al: Medical conferences in the era of environmental conscientiousness and a global health crisis: The carbon footprint of presenter flights to pre-COVID pediatric urology conferences and a consideration of future options. J Pediatr Surg 56:1312-1316, 2021
10. Duane B, Lyne A, Faulkner T, et al: Webinars reduce the environmental footprint of pediatric cardiology conferences. Cardiol Young 31:1625-1632, 2021
11. Lewy JR, Patnode CD, Landrigan PJ, et al: Quantifying the climate benefits of a virtual versus an in-person format for an international conference. Environ Health 21:71, 2022
12. Periyasamy AG, Singh A, Ravindra K: Carbon emissions from virtual and physical modes of conference and prospects for carbon neutrality: An analysis from India. Air Soil Water Res 15: 117862212210932, 2022
13. U.S. Census Bureau: Gazetteer Files. https://www.census.gov/
14. United States Department of Transportation: Geospatial at the Bureau of Transportation Statistics
15. Hotle S, Mumbower S: The impact of COVID-19 on domestic U.S. air travel operations and commercial airport service. Transp Res Interdiscip Perspect 9:100277, 2021
16. Federal Aviation Administration: Passenger Boarding (Enplanement) and All-Cargo Data for U.S. Airports
17. The World Bank: Airports Geospatial Data. 2023. https://datacatalogfiles.worldbank.org/ddh-published/0038117/DR0046411/airport_volume_airport_locations.csv?versionId=2023-01-19T11:18:11.1423140Z
18. Hijmans RJ, Williams E, Vennes C: Geosphere: Spherical Trigonometry. 2022
19. Vincenty T: Direct and inverse solutions of geodesics on the ellipsoid with application of nested equations. Surv Rev 23:88-93, 1975
20. DataHub: Datopian, Airport Codes
21. Miller A: Airport Deserts—Exploring the Distance between Airports and the Cities They Serve [Data Study]. 2020. https://upgradedpoints.com/
22. Average Distance to Nearest Airport. Mark-Pearson. 2012
23. Center for Sustainable Systems: Carbon Footprint Factsheet
24. United States Environmental Protection Agency: Tailpipe Greenhouse Gas Emissions From a Typical Passenger Vehicle, 2016
25. Hotel Footprint Calculator: Green View Hotel Footprinting Tool
26. MyClimate S: Calculate Your CO_2 Emissions Now!
27. The White House: FACT SHEET: Health Sector Leaders Join Biden Administration's Pledge to Reduce Greenhouse Gas Emissions 50% by 2030. 2022
28. Singh H, Eckelman M, Berwick DM, et al: Mandatory reporting of emissions to achieve net-zero health care. N Engl J Med 387:2469-2476, 2022
29. Atwoli L, Baqui A, Benfield T, et al: Call for emergency action to limit global temperature increases, restore biodiversity, and protect health. N Engl J Med 385:1134-1137, 2021
30. Spinellis D, Louridas P: The carbon footprint of conference papers. PLoS ONE 8:E66508, 2013
31. Zotova O, Pétrin-Desrosiers C, Gopfert A, et al: Carbon-neutral medical conferences should be the norm. Lancet Planet Health 4:e48-e50, 2020
32. United States Environmental Protection Agency: Scope 1 and Scope 2 Inventory Guidance. 2020
33. Chan A, Cao A, Kim L, et al: Comparison of perceived educational value of an in-person versus virtual medical conference. Can Med Educ J 12:65-69, 2021
34. Raby CL, Madden JR: Moving academic conferences online: Aids and barriers to delegate participation. Ecol Evol 11:3646-3655, 2021
35. Gottlieb M, Sebok-Syer SS, Bawden A, et al: "Faces on a screen": A qualitative study of the virtual and in-person conference experience. AEM Educ Train 6:e10827, 2022
36. Ostler D, Steger J, Bernhard L, et al: "Hybrid" scientific conference: Lessons learned from the digital annual meeting of the CARS international conference during the Covid-19 pandemic. Innov Surg Sci 6:115-123, 2022
37. Schwartz RA, Rubins S, Rubins AY: Therapeutic advances from the 16th Baltic Association of Dermatovenereologists Congress, University of Latvia, Riga, Latvia hybrid conference: Zoom the skin and save lives! 4 to 5 September 2020. Dermatol Ther 33:e14400, 2020
38. Richter JG, Chehab G, Knitza J, et al: Deutscher Rheumatologiekongress virtuell—Erfolgreich tagen trotz Pandemie [Annual meeting of the German Society for Rheumatology going virtual-successfully defying the pandemic]. Z Rheumatol 80:399-407, 2021
39. Sonic Foundry: Event Camp and Sonic Foundry's Mediasite Events Produce Successful Hybrid Event Series. 2011. https://sonicfoundry.com/newsroom/event-camp-and-sonic-foundrys-mediasite-events-produce-successful-hybrid-event-series/
40. One Planet Network: Sustainable Events Guide: Give Your Large Event A Small Footprint. 2018
41. Network Greener: Conference Emissions Calculator. https://networkgreener.com/
42. Aravamuthan B, Landsness EC, Silbermann E: ANA webinars: Implementation of a conference-based virtual networking event. Ann Clin Transl Neurol 8:525-528, 2021
43. Parncutt R, Lindborg P, Meyer-Kahlen N, et al: The multi-hub academic conference: Global, inclusive, culturally diverse, creative, sustainable. Front Res Metr Anal 6:699782, 2021
44. Seuront L, Nicastro KR, Zardi GI: Heads in the clouds: On the carbon footprint of conference-seeded publications in the advancement of knowledge. Ecol Evol 11:15205-15211, 2021
45. Tao Y, Steckel D, Klemeš JJ, et al: Trend towards virtual and hybrid conferences may be an effective climate change mitigation strategy. Nat Commun 12:7324, 2021
46. Yates J, Kadiyala S, Li Y, et al: Can virtual events achieve co-benefits for climate, participation, and satisfaction? Comparative evidence from five International Agriculture, Nutrition and Health Academy Week conferences. Lancet Planet Health 6:e164-e170, 2022