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Carbon footprint of the 2021 and 2022 AAPOS annual meetings
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The COVID-19 pandemic necessitated a virtual annual meeting of the American Association for Pediatric Ophthalmology and Strabismus (AAPOS) in 2021, thus eliminating carbon emissions from travel to and from the planned meeting venue in Boston, Massachusetts. We found that the reduced carbon footprint of the virtual meeting saved 1,282 metric tonnes of CO₂ emissions compared with estimated CO₂ emissions for travel if the meeting had taken place in person, or 880 metric tonnes relative to the projected emissions associated with the in-person 2022 annual meeting in Scottsdale, Arizona. An entirely virtual or hybrid AAPOS meeting would reduce its environmental footprint and increase the opportunity for national and international participation and education.

Carbon dioxide emissions are the primary driver of climate change, and international medical conferences contribute substantially to greenhouse gas emissions.1 We endeavored to study the impact of one subspecialty conversion from an in-person format to fully virtual on the carbon dioxide equivalent (CO₂e) resulting from that meeting.

Methods
The cities and countries of origin for deidentified attendees of the virtual 2021 AAPOS Annual Meeting (scheduled for Boston, MA) were obtained from AAPOS, and a registrant’s likely transportation mode was identified from the attendee’s listed city of registration. Attendees from New England (Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and Rhode Island) were assumed to drive. Driving emissions from the zip code of origin were calculated using Google Maps (https://www.google.com/maps) and guidelines on passenger vehicles from the US Environmental Protection Agency (EPA).2 For attendees outside of New England, flight emissions for economy and business class from the airport closest to the city of origin to Boston Logan Airport were tabulated using Flight Emissions Calculator (Offsets, Vancouver, BC, https://www.offsetters.ca/education/calculators/flight-emissions-calculator), which assigns higher emissions to business class due to lower passenger density. Emissions were tallied in metric tonnes (1000 kg) of CO₂ equivalents, “tonnes CO₂e.” It was assumed that 90% of participants used economy class and 10% flew via business class.1

The cities and countries of origin for deidentified registrants of the in-person 2022 Annual Meeting of AAPOS (Scottsdale, AZ) were obtained as of February 23, 2022, prior to the closing of preregistration. Attendees from Arizona were assumed to drive to the meeting, and driving emissions were calculated using the US EPA guidelines, as above. All other attendees were assumed to have flown, and flight emissions from the major airport closest to the city of origin to Phoenix International Airport were calculated, as above.

Results
A total of 1,212 persons attended the virtual 2021 annual meeting, saving 1,282 tonnes of CO₂e (1.06 tonnes/attendee). The CO₂e saved varied according to country of origin (Table 1), ranging from 0.58 tonnes per Canadian attendee to 3.24 tonnes per international attendee. The geographic distribution of the US attendees (Figure 1) reflects a larger number of attendees from the East and Midwest.

The CO₂e/attendee for the 2022 meeting is presented in Table 2. US attendees of the 2022 annual meeting in Scottsdale incurred 19% greater CO₂ emissions than if they had attended the 2021 annual meeting in Boston (0.76 vs 0.64 tonnes CO₂/attendee) because of the venue location relative to the population of attendees (Figure 1). There were more international attendees from outside North America for the 2021 meeting than for 2022 preliminary registration (194 vs 67). In 2021, 84% of the registrants were from North America, compared with 92% in 2022.

Discussion
In 2021, 1,282 tonnes of CO₂ emissions were saved because of the virtual meeting format. This is equivalent to the emissions from 264 passenger vehicles driven for 1 year, or the carbon sequestered by 1,485 acres (6 sq km) of US forests in 1 year (https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator).

The calculated CO₂ emissions saved per capita (1.06 tonnes/person) by avoiding travel for the 2021 meeting is similar to that found by Wortzel and colleagues4 (1.19 tonnes/person) for the 2018 meeting of the American Psychiatric Association in New York, although 25% of their 18,000 attendees were from outside North America compared with only 15% of 2021 AAPOS attendees.

Klower and colleagues1 reported on ways to decarbonize travel by the 28,000 attendees of the 2019 Fall Meeting of the American Geophysical Union in San Francisco, California. They found that 75% of the emissions were generated by the travel of 35% of the attendees, and that, because
of the large proportion of international attendees, the emissions were about 3 tonnes CO₂e/attendee for meeting travel. The authors advocated for increasing virtual attendance when possible, moving to a multihub meeting format to lessen travel distances, and changing to a biennial format.

A more comprehensive analysis of the total energy consumption of virtual, in-person, and hybrid meetings was presented by Tao and colleagues. Via life cycle analysis and complex analysis of multiple factors contributing to environmental impact (including, but not limited to, transportation, computing energy usage, water usage, food production/consumption, waste, metal depletion, and freshwater and marine ecotoxicity), the authors determined that “transitioning from in-person to virtual conferencing can substantially reduce the carbon footprint by 94% and energy use by 90%. For the sake of maintaining more than 50% of in-person participation, carefully selected hubs for hybrid conferences have the potential to slash carbon footprint and energy use by two-thirds.”

There are benefits to in-person meetings, including enhanced professional education with participation in wet labs and interactions at workshops that would not be possible in virtual form. In-person meetings are also valuable for fostering collaboration and connections in a small subspecialty, mentoring, networking, and development of business partnerships among individuals who might not have met otherwise. Finally, there are economic benefits to the host city, to airlines, and to the AAPOS organization.

Increasing virtual participation has potential benefits in addition to reducing environmental impact: less time preparing for travel and travel itself, less time lost to patient care, research, and family, opportunity for a customized audio and visual experience, and participation of a larger and more diverse audience. While there is concern that academic productivity and advancement might suffer if virtual meetings became commonplace, Wynes and colleagues, in a study of 708 travelers among faculty at the University of British Columbia, found no relationship between academic productivity (adjusted for academic rank and discipline) and emissions from air travel. University salary, however, was related to emissions.

| Country of origin | No. attendees (%) | Tonnes CO₂e per attendee | Total tonnes CO₂e per group (%) |
|-------------------|-------------------|--------------------------|--------------------------------|
| United States     | 969 (80)          | 0.64                     | 618.06 (48)                    |
| Canada            | 39 (3)            | 0.58                     | 22.62 (2)                      |
| Mexico            | 10 (1)            | 1.23                     | 12.29 (1)                      |
| Other international| 194 (16)          | 3.24                     | 629.25 (49)                    |
| Overall           | 1212 (100)        | 1.06                     | 1282.22 (100)                  |

CO₂e, CO₂ equivalent in tonnes; Tonnes, metric tons (1000 kg) CO₂ emissions. Values indicate metric tonnes of savings when the meeting was converted from in-person in Boston to virtual.
Table 2. CO₂ emissions produced by the 2022 AAPOS Annual Meeting in Phoenix, Arizona\textsuperscript{a}

| Country of origin | No. attendees (%) | Tonnes CO₂\textsubscript{e} per attendee | Total tonnes CO₂\textsubscript{e} per group (%) |
|-------------------|-------------------|----------------------------------------|------------------------------------------|
| United States     | 767 (89)          | 0.76                                   | 585.34 (67)                              |
| Canada            | 19 (2)            | 0.93                                   | 17.79 (2)                                |
| Mexico            | 9 (1)             | 0.49                                   | 4.44 (1)                                 |
| Other             | 67 (8)            | 4.06                                   | 272.14 (31)                              |
| International     |                   | 1.02                                   | 879.71                                   |
| Overall           | 862 (100)         |                                        |                                          |

\textsuperscript{a}CO₂\textsubscript{e}, CO₂ equivalent in tonnes; Tonnes, metric tons (1000 kg) CO₂ emissions.

The current study is limited in that it likely underestimated the environmental impact of the annual meeting. The calculations did not include travel for AAPOS staff (n = 8), guests (unknown number), or staff of exhibitors and sponsors (120-150 in 2022). Transportation to and from airports at the home and meeting locations was not considered. There are also potential sources of overestimation: the percentage of AAPOS members taking business class may have been overestimated, and more than one AAPOS member is likely to take any particular flight in the days leading up to and following the meeting. The AAPOS meeting alone is not likely to inspire airlines to add additional flights—that is, the planes would have flown anyway; however, if all academic conferences were to switch to a hybrid model, it would ultimately affect the number of flights flown in any year. A third limitation is that final registration numbers for the 2022 meeting were likely larger than those used for the calculations at the time the study was performed.

In conclusion, the 2021 virtual annual meeting of AAPOS saved 1,282 tonnes CO₂\textsubscript{e}. The environmental footprint of AAPOS could be reduced by switching to entirely virtual, hybrid, or biennial meeting formats, selecting venue locations that minimize emissions. The impact of such a shift on collegiality, networking, and professional advancement would require further study.

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Netarsudil-induced corneal honeycombing in childhood glaucomas

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Netarsudil is a hypotensive drug that reduces intraocular pressure (IOP). Although it is used to treat corneal decompensation/edema in normotensive eyes, we observed the occurrence of corneal epithelial edema with corneal honeycombing in children with uncontrolled IOP (primary or secondary glaucoma) on maximal topical medication following netarsudil (0.02%) therapy of 2 weeks. Of 16 eyes of 16 children, 9 (56%) developed corneal honeycombing. They were younger than those without honeycombing (median age, 3.1 vs 9.7 years [P = 0.016]), had higher baseline IOP (35.6 ± 7.4 vs 27.2 ± 5.6 mm Hg [P < 0.001]), and usually had preexisting corneal edema (7/9 eyes vs none [P < 0.001]).