Carbon Emissions from Virtual and Physical Modes of Conference and Prospects for Carbon Neutrality: An Analysis From India

Authors: Periyasamy, Aravind Gandhi, Singh, Amarjeet, and Ravindra, Khaiwal

Source: Air, Soil and Water Research, 15(1)

Published By: SAGE Publishing

URL: https://doi.org/10.1177/11786221221093298

Carbon Emissions from Virtual and Physical Modes of Conference and Prospects for Carbon Neutrality: An Analysis From India

Air, Soil and Water Research
Volume 15: 1–10

DOI: 10.1177/11786221221093298
SAGE

Aravind Gandhi Periyasamy, Amarjeet Singh and Khaiwal Ravindra

Department of Community Medicine and School of Public Health, Postgraduate Institute of Medical Education and Research, Chandigarh, India

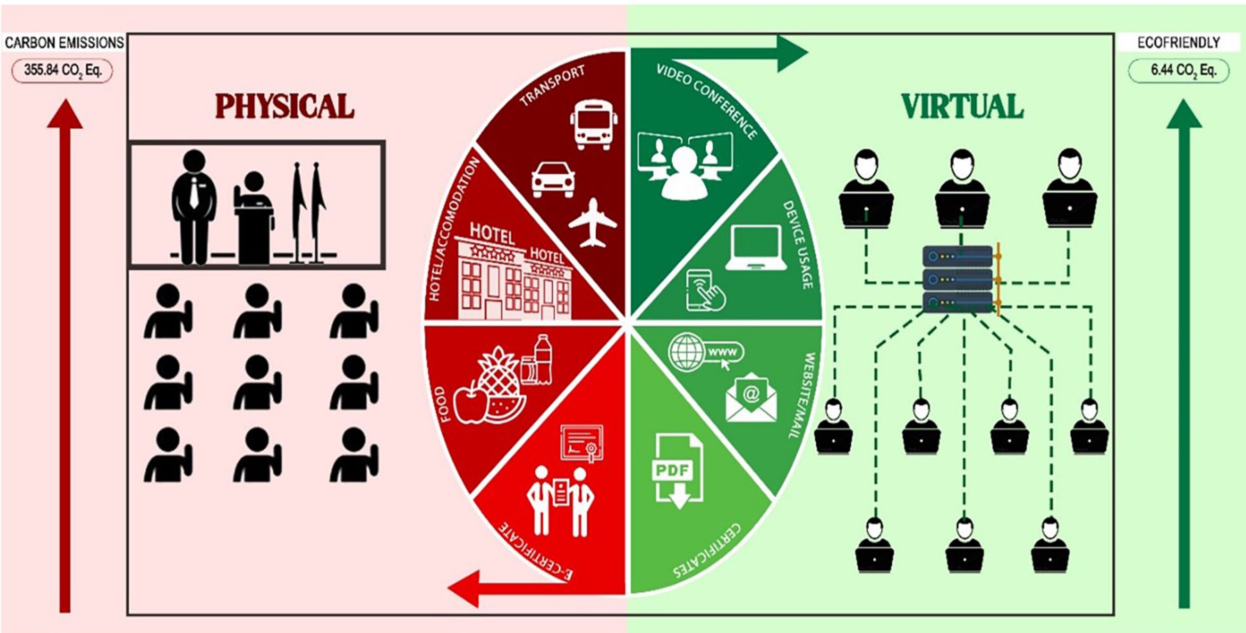
ABSTRACT: Virtual conferences are environment-friendly alternatives to physical conferences. COVID-19 pandemic has increased the use of virtual conferences. However, they are not without their share of impact on the environment. We assessed the carbon emissions (CE) of a three day national public health conference with 1474 attendees held in virtual mode and the potential CE saved compared to the physical mode. The CE of the virtual conference were estimated to be 6.44 Metric Tonne (MT) carbon dioxide (CO_2) Equivalent (Eq). Potential CE that would have resulted from the physical mode of the conference were 355.85 MT CO_2 Eq which is 55 times higher than the virtual mode. The live video streaming of the proceedings was the highest contributor to the virtual conference's overall CE (81.5%). A digitally sober conference would have emitted 1.27 MT CO_2 Eq, translating to a CE reduction of 80.3% from the estimated virtual conference emission. Academic conferences should strive to become carbon neutral by adopting the virtual mode of conferencing, and within that, digital sobriety should be the policy of action. Policies to motivate the adoption of virtual conferencing and digital sobriety need to be undertaken at the organizational and individual levels.

KEYWORDS: Environment-friendly, carbon emission, national conference, virtual conference emission

RECEIVED: October 8, 2021. **ACCEPTED:** March 23, 2022.

TYPE: Original Research

CORRESPONDING AUTHOR: Ravindra Khaiwal, Department of Community Medicine and School of Public Health, Postgraduate Institute of Medical Education and Research, Sector 12, Chandigarh 160012, India. Email: khaiwal@yahoo.com



Highlights

- Virtual conferences are environment-friendly alternatives to physical conferences
- Carbon emissions (CE) of a virtual conference were estimated to be 6.44 MT CO_2 Eq
- Potential CE due to physical mode were estimated 55 times higher (355.85 MT CO_2 Eq)
- A digitally sober conference would have emitted 1.27 MT CO_2 Eq only
- Incentives and policy impetus must be given to promote virtual conferences

Background

Across the world, scientific conferences and conventions are being carried out to improve the sharing of knowledge and collaboration (Fraser et al., 2017; Raby & Madden, 2021). Most of these conferences happen in physical mode, which requires travel and other amenities for the delegates and the speakers. The cost incurred by such a physical mode of the conference is high, both in the economic and environmental context. The substantial amount of CO_2 emitted in these conferences has been documented outside India (Desiere, 2016; Kitamura et al., 2020; Spinellis & Louridas, 2013). The carbon emission from the travel component of a large conference was equivalent to the weekly emission of a city (Klöwer et al., 2020). Virtual mode of conferences and scientific deliberations are environment-friendly alternatives to such physical conferences. Virtual conferences are a critical positive step toward climate change action (Abbott, 2020; Jordan & Palmer, 2020). COVID-19 pandemic resulted in the restrictions in movement of people at the internal, national and local levels. This movement restriction has increased the virtual mode of meetings, education and scientific deliberations to unprecedented levels (Faber, 2021; Jordan & Palmer, 2020).

Multiple modalities and platforms have been utilized for such virtual meetings and conferences. Organizations and events worldwide report their carbon emission (CE) and their commitment towards the environment by offsetting the emissions and endeavoring to be carbon neutral or carbon negative (Faber, 2021). However, the virtual mode of conferences is not without its share of impact on the environment. The hardware, software, servers, data consumed, and networking used produce a significant carbon footprint. Worldwide it has been estimated that 3.7% of the total CE is due to digital and information technologies (Ferreboeuf, 2019). The virtual conferences which also use these modalities contribute to the carbon footprint (Faber, 2021). Strategies to reduce carbon emissions from virtual events are also being discussed worldwide. Digital sobriety is being proposed as one of the methods to reduce carbon emissions from virtual events. Digital sobriety mainly consists of "buying least powerful equipment possible, changing them as least often possible, and reducing unnecessary energy-intensive uses" (Ferreboeuf, 2019).

In order to assess the actual environmental impact of the virtual mode of conferences, it is essential to do a comparative analysis of the carbon emitted from the virtual conferences and the potential carbon that would have been emitted from their physical counterparts.

In the current study an attempt has been made to quantify and compare the CE from various virtual meetings and conferences with their physical counterparts. The majority of the previous studies compared the virtual and physical meetings with a limited scope in duration and participants. Faber et al., in their framework, formulated to assess the carbon emission of the virtual conference from the United States of America (USA) assessed the emissions from the virtual conference and compared it with its transport component of the physical counterpart. The virtual conference saved 66 times of CE than that would have emitted from the transportation for the supposedly physical conference (Faber, 2021). However, the following limitations were there in their analysis: the conference was hosting 207 delegates for a single day, 6-hour event, and the accommodation was not found a necessary emitter in it. All the delegates attended the conference directly through Zoom as participants (Faber, 2021).

Hence, the findings cannot be applied to more extensive and more prolonged conferences where more than 1,000 participants attend for 2 to 3 days, requiring accommodation. In light of this, the CE equations change within the virtual settings and between the virtual and physical modes of conferences. We also found a lacuna in the literature on the environmental impact of virtual conferences from India. Health and healthcare-related conferences and meetings should be aware of their carbon footprints, as the environment is an essential determinant of health. They need to assess and offset their CEs. Hence, we conducted the following study to assess the potential carbon footprints/emissions saved during the three-day Annual Conference of the Indian Association of Preventive and Social Medicine (IAPSM) conducted in virtual mode.

Material and Methods

Study design: Record based, cross-sectional study

Study settings: IAPSMCON-2021 conference. The 48th Annual Conference of the Indian Association of Preventive and Social Medicine (IAPSMCON, 2021) was held from 19th to 21st March 2021. Due to the COVID-19 situation, IAPSCOM 2021 was held in virtual mode for the first time. The conference was hosted by the Department of Community Medicine and School of Public Health, Postgraduate Institute of Medical Education & Research (PGIMER), Chandigarh, India. The total number of registered participants for the conference was 2046. The registered delegates were given unique login credentials to attend and participate in various activities of the conference. The conference was divided into multiple sessions, with a duration of 1 to 1.5 hours per session. The sessions were conducted virtually through Zoom meetings, in which the dignitaries, organizers and the technical partners were provided with the link to join as participants. This Zoom meeting was broadcasted in real-time to the delegates through a dedicated website. The conference was attended by community medicine specialists, public health experts and professionals, faculty, students, and researchers across India.

Methodology

The name blinded list of the delegates, chairpersons, and speakers of the IAPSMCON 2021 and their registered place of work/study was collected from the conference secretariat. The number of registered delegates who logged into the virtual conference portal (attendees) was obtained from the technical partner who assisted in hosting the conference. The total number of attendees came to be 1,474. A post-conference feedback survey was conducted among the attendees. The proportion of probable attendees had the conference been held in physical

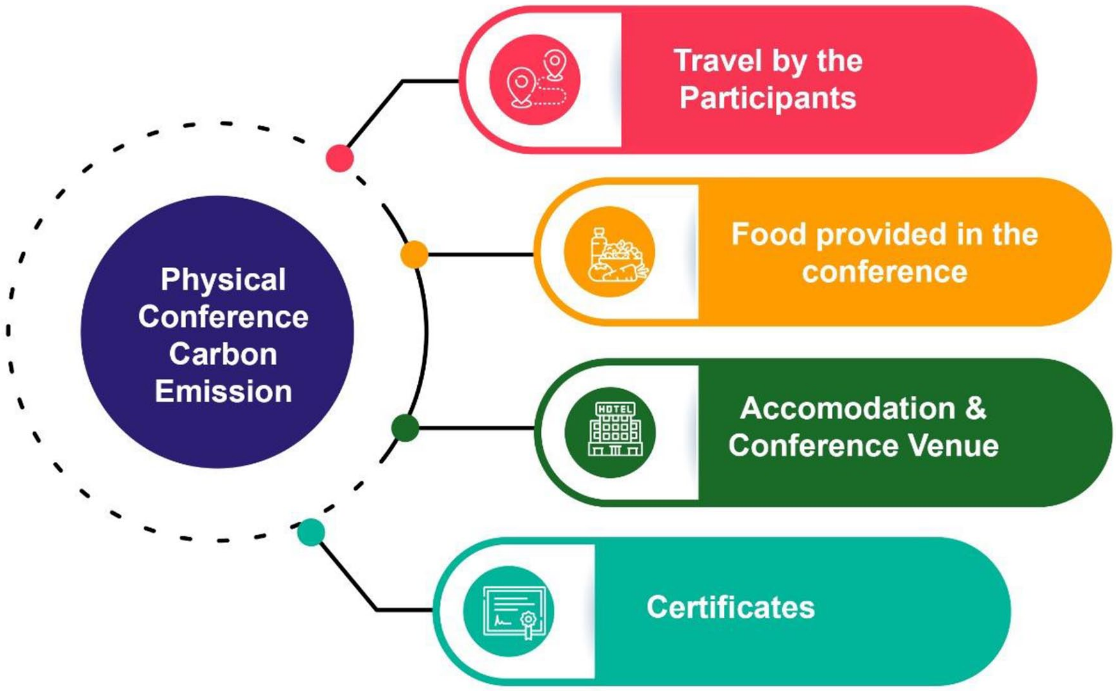


Figure 1. Domains included as areas of carbon emission in physical conference.

mode, and their preferred mode of transport to attend the physical conference were obtained from the conference feedback survey. The response rate of the feedback survey was 15% (248/1474). This was extrapolated to overall attendees of the virtual conference. The potential carbon footprint of the significant physical conference activities such as transportation, accommodation, food and certificates was calculated for the proportion of delegates who would have attended the physical conference (Figure 1).

Transportation. The CO_2 Eq, which would have been emitted due to the traveling by participants for the physical conference, was estimated based on the proportion of virtual attendees who would have attended the physical conference. Among the 1,474 delegates who attended the virtual conference from India, 65% would have also participated in the conference had it been physical. The potential distance which the attendees had to travel for attending the conference was calculated as the shortest distance between the capital city of the state/district and Chandigarh (Flight Distance and Duration Calculator, n.d.; Google Maps [WWW Document], n.d.) Then, the two-way distance was calculated. We considered three modes of transportation for travel by the attendees: Rail, air and road. The mode of transport was decided based on the state and country of origin. For the speakers from outside India, we considered airways as the only means of transport. For the delegates who hail from states other than Punjab, Haryana and Himachal Pradesh, the mode of transport was distributed based on the preference given by the attendees for a potential physical conference. Among them, 65% would have preferred airways as a mode of transport and 17% preferred railways, while 8% preferred roadways.

Sensitivity analysis was conducted by creating three more scenarios: (i) all attendees came by railways, (ii) all attendees came by airways, and (iii) 50% of the attendees came by railways and 50% came by airways. The capital of the states of Punjab and Haryana is Chandigarh. The shortest distance between Shimla (capital of Himachal Pradesh) and Chandigarh was less than 120 kms. Hence, we calculated the distance between Chandigarh and the district headquarters of the attendees from these three states and considered roadways as the mode of transport. A sedan car was assumed to be the vehicle of choice for road travel. Participants from Chandigarh were excluded from the transport analysis. CEs per km for these modes and types of transport were obtained for India (Gajjar & Sheikh, 2015a, 2015b; India GHG Program, 2015).

Accommodation and the conference hall. As the conference was held for 3 days, we assumed that each attendee would have stayed for 3 days and two nights. The chairpersons would have been lodged in a four-star hotel under single occupancy, and the speakers in the single occupancy rooms of a three-star hotel. The delegates were assumed to have taken a shared occupancy (two per room) in a two-star hotel. The space necessary to conduct the conference was calculated under a 4-star hotel. The CE based on the above assumptions was calculated for the hotel rooms as well as the supposed conference hall, using an online tool (Hotel Footprinting Tool [WWW Document], n.d.). The online tool used in the present study was Hotel Footprint Tool ("Hotel Footprinting Tool," n.d.). The tool helped to calculate the carbon emission of the stays and meetings conducted in the hotels. It uses actual data collected from around 20,000 hotels from over 500 locations across the world, which has been obtained from the 2018 data set of the Cornell

Figure 2. Domains included as areas of carbon emission in virtual conference.

Hotel Sustainability Benchmarking Tool ("Cornell Hotel Sustainability Benchmarking Index – Greenview," n.d.). The specific methodology used to calculate the carbon footprint by the online tool was formulated by the Hotel Carbon Measurement Initiative (HCMI) (Hotel Carbon Measurement Initiative [HCMI] [WWW Document] (n.d.)). HCMI factors in the electricity used for the activities carried out in the conference hall while calculating its CE. The HCMI is the commonly used method by the hotel industry in order to calculate the carbon emissions per guest night or area of meeting space. This HCMI based assessment of carbon emission assists in making the data and calculations employed are uniform as well as comparable across the locations and hotels.

Food. CE from the food served at the conference was calculated by formulating three meals and two snacks per day. Menu for each meal and snacks were formulated, and the CE of each meal was calculated using an online tool (Food carbon footprint calculator –My Emissions [WWW Document], n.d.). The three-day potential CE from the food per participant was calculated, and the data were extrapolated to the probable number of physical conference attendees. The online tool used in the present study was "My Emissions." It has a built-in food emission database, which is updated based on the data from "life cycle assessments" of various food items. Specific carbon emission values for each food during the main stages of its life cycle are used for calculating overall emissions. The four main stages of the food' life cycle included in the "My Emission" calculation are farming, processing, packaging and transportation, which includes raw material as well as the finished product to the final consumer (Our Data – My Emissions [WWW Document], n.d.).

Certificates. The certificates for the delegates, speakers, chairpersons and presenters at the conference were included to calculate CEs.

The areas which contribute toward the carbon emission in virtual conferences are depicted in Figure 2.

Virtual platform. The conference was conducted in a hybrid virtual method, that is, the sessions were conducted in the Zoom platform with speakers, chairpersons, organizers and the technical partner as the participants in the platform. At the same time, the delegates visualized this meeting as a broadcast through the technical partner' website. Hence, we calculated the CE of the IT platform used in the virtual conference under the following heads: Streaming of the conference by the delegates, Zoom meeting usage by the speakers, chairpersons, organizers, and the technical partner, server usage at the Zoom data center, Emails sent to the delegates and dignitaries, Page views of the website hosting the conference, computers used by the attendees for the virtual conference. Each session had an average of 15 participants in the Zoom platform. The CE for visiting the conference website page was calculated by assuming that each delegate would have visited 12 tabs available in the conference website at least once during the entire conference and logged out and reloaded the pages during the conference breaks. Hence, a delegate would have done an average of 21-page visits during three days of the conference (What's the Carbon Footprint of Your Website? | Climate Protection |

RESET.org [WWW Document], n.d.). The CE of the server were calculated using the formula (1), (Faber, 2021)

$$E_e * S * Ws_* H_c \quad (1)$$

Where Ee is the electricity emissions (kg CO_2-eq/kWh), S is the number of servers (assumed to be one), Ws is the power rating of servers (kW/server), and Hc is the total conference duration (hour)

The average CE of electricity in India was obtained from the central audit report of the Power ministry (Bhawan & Puram, 2018). Although Zoom servers are located in India, the CE data for the same could not be found from the literature search. Hence we used the data available from the USA (Faber, 2021). The devices used for attending the conference was obtained from the conference feedback received through email from the participants. Among the ones responded, more than 90% of the participants used either laptops (59%) or smartphones (34%) to watch the conference proceedings. Hence these two devices were taken to estimate the device CO_2 emissions for analysis. The average of the CE emission reported by the laptop brands used by the delegates for attending the conference was calculated, and the total CE emission from the laptops was assessed.

Among the smartphones, only one of the brands published the CE per smartphone by Life cycle analysis (LCA). Hence, this data was used for other smartphones as well. Since we did not have data on the models of that brand used by the attendees, we took the average CE of India's top three selling models of that brand (Environment - Apple [WWW Document], n.d.; The Most Popular iPhones – 2020," n.d.). The CEs of these devices were obtained based on their LCAs (Faber, 2021). The average lifetime of the laptops was taken to be 4 years (Faber, 2021) and mobile phones in India were taken to be 6 years (Life of a Mobile Phone in India [WWW Document], n.d.; "New Uses for Old Phones: Upcycling the Rotary Dial Phone in the Age of the Smartphone – OCAD University Open Research Repository [WWW Document], n.d.). The average usage of laptops and smartphones per day was assumed to be 2 hours and 3 hours (Faber, 2021; MBiT index 2021 | Nokia [WWW Document], n.d.), respectively. The median duration of the conference attended by the laptop and smartphone users was found to be 8 hours and 9 hours, respectively, from the feedback. The CE share of those devices during the conference period was calculated based on equation (2) (Faber, 2021).

$$P_c * E_c * Hc / \left(Y * 365.25 * H_d\right) \quad (2)$$

where *Pc* is the number of participants which equals the number of devices used (laptop or smartphone), *Ec* is the devise emissions in kg CO2-eq/devise), *Hc* is the median duration of the conference attended by a delegate in hours, Y is the years of the useful life of the laptop/smartphone, *Hd* is the daily hours of laptop/smartphone use.

CE happened due to the virtual systems and data usage during the conference was calculated for activities such as streaming and watching the conference proceedings virtually, (Obringer et al., 2021) emails sent to delegates, speakers, chairpersons, and presenters, (Infographic: The Carbon Footprint of the Internet | ClimateCare [WWW Document], n.d.) e-certificates generated and downloaded, virtually.

Data analysis

Data collation and analysis were done using MS Excel. The potential CE from various activities was calculated for the physical and virtual modes of the conference. The cumulative CE of the physical and virtual conference was calculated and compared. Sensitivity analysis was done for the scenarios mentioned earlier, with varying proportions of attendees choosing different transport modes.

Ethical consideration

Since it was a record-based, anonymized secondary data obtained from the conference registry, an exemption from the ethical review was obtained from the Institute Ethics Committee, Postgraduate institute of medical education and research, Chandigarh.

Results

The CE of the virtual conference, IAPSMCON 2021, was calculated to be 1.934 to 6.442 MT CO_2 Eq, depending on the quality of the video in which the delegates streamed the conference, that is, High definition (HD) or Standard Definition (SD), and whether the speakers and dignitaries kept the video switched on or off in the Zoom during the proceedings. (Table 1 and Supplemental Appendix 1). The per capita emission of attendees of the virtual conference ranged from 0.001 to 0.004 MT CO_2 Eq.

During the conference, the majority of the CE was from the streaming of the proceedings by the delegates and dignitaries (81.53%), followed by the devise usage (15.21%).

The potential CE, if the conference was held physically, was 355.843 MT CO_2 Eq (Table 2 and Supplemental Appendices 2 and 3). The potential per capita emission among the probable 958 delegates who would have attended the physical conference was 0.371 MT CO_2 Eq.

The majority of the potential CE from the physical mode conference would have been generated by the transport activity which the delegates would have undertaken to attend the conference (72.74%). The second and third most contributors toward CE would have been the accommodation required for the attendees (17.88%) and the food served during the conference (9.37%) (Figures 3).

Table 1. Carbon Emission under various aspects during the virtual mode.

EMISSION HEADS	SCENARIO 1: HD STREAMING AND VIDEO SWITCHED ON DURING THE VC (CO_2 EQ MT)	SCENARIO 2: SD STREAMING AND VIDEO SWITCHED OFF DURING THE VC (CO_2 EQ MT)
Video Streaming	5.252	0.744
Emails	0.051	0.051
E certificates	0.003	0.003
Website Page Views	0.143	0.143
Device usage	0.980	0.980
Zoom server usage	0.013	0.013
Total	**6.442**	**1.934**
Per capita emission	**0.004**	**0.001**

VC = video conferencing.

Table 2. Potential CE under various aspects during the physical conference.

EMISSION HEADS	PHYSICAL MODE (CO_2 EQ MT)
Transport	258.851
Accommodation	63.630
Certificates	0.015
Food	33.348
Total	**355.843**
Per capita emission	0.371

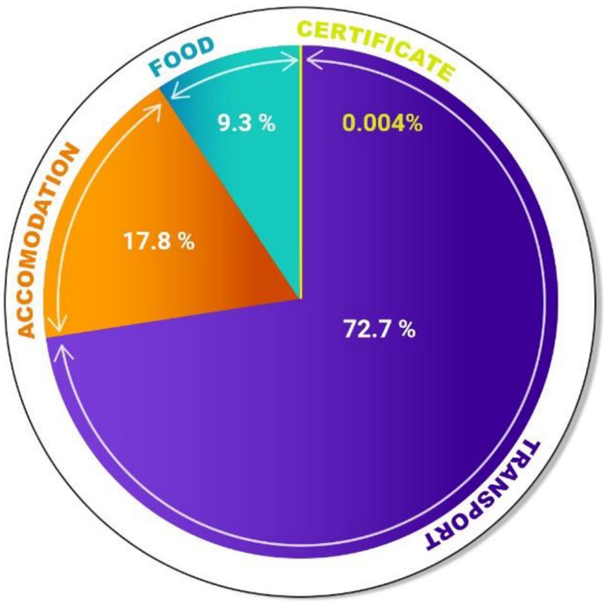


Figure 3. Potential proportion of CE from various activities of the physical conference: IAPSMCON 2021.

The Potential CE saved during the IAPSMCON 2021 by adopting the virtual mode was 349.401 to 353.909 MT CO_2 Eq (Figures 4)

Discussion

It has been reported that the global event industry constitutes more than 10% of the global CO_2 emission, which warrants greater attention from the environmental protection point of view (Tao et al., 2021). Scientific conferences are a significant source of carbon emitter (Raby & Madden, 2021; Wortzel et al., 2021). Virtual mode of conferences is being ushered in as a potential solution for reducing the environmental impact (Duane et al., 2021; Roberts & Godlee, 2007; van Ewijk & Hoekman, 2021).

Potential CE that would have resulted from the physical version of IAPSMCON 2021 was 355.85 MT CO_2 Eq. The per capita CE for a year in India is 2.7 MT CO_2 Eq. (The Carbon Brief Profile: India [WWW Document], n.d.), while the potential per capita emission in IAPSMCON 2021 was 0.35 MT CO_2 Eq. The three-day physical conference constituted 13.8% of the total CE of the attendees, which they would have contributed during the whole year. On the other hand, the total CE of the virtual IAPSMCON 2021 was assessed to be 6.44 MT CO_2 Eq, which came to be less than the CE of three Indians in a year. A digitally sober conference would have further reduced the CE of the conference to even lower than that of the single person' CE per year in India.

The liberal estimate in our analysis found that the physical mode of the conference would have emitted 55 times higher CO_2 Eq than virtual conference (355.84 MT CO_2 Eq vs. 6.44 MT CO_2 Eq). Raby et al. reported a 200 times reduction in the CE due to the Association for the Study of Animal Behaviour (ASAB) conference in virtual mode (Raby & Madden, 2021). In their analysis from the Air Miner' conference from the United States of America (USA), Faber et al. estimated 66 times CE savings from the virtual mode of proceedings (Faber, 2021). The potential per capita emission from the physical mode of our conference was 0.37 MT CO_2 Eq, which is lower

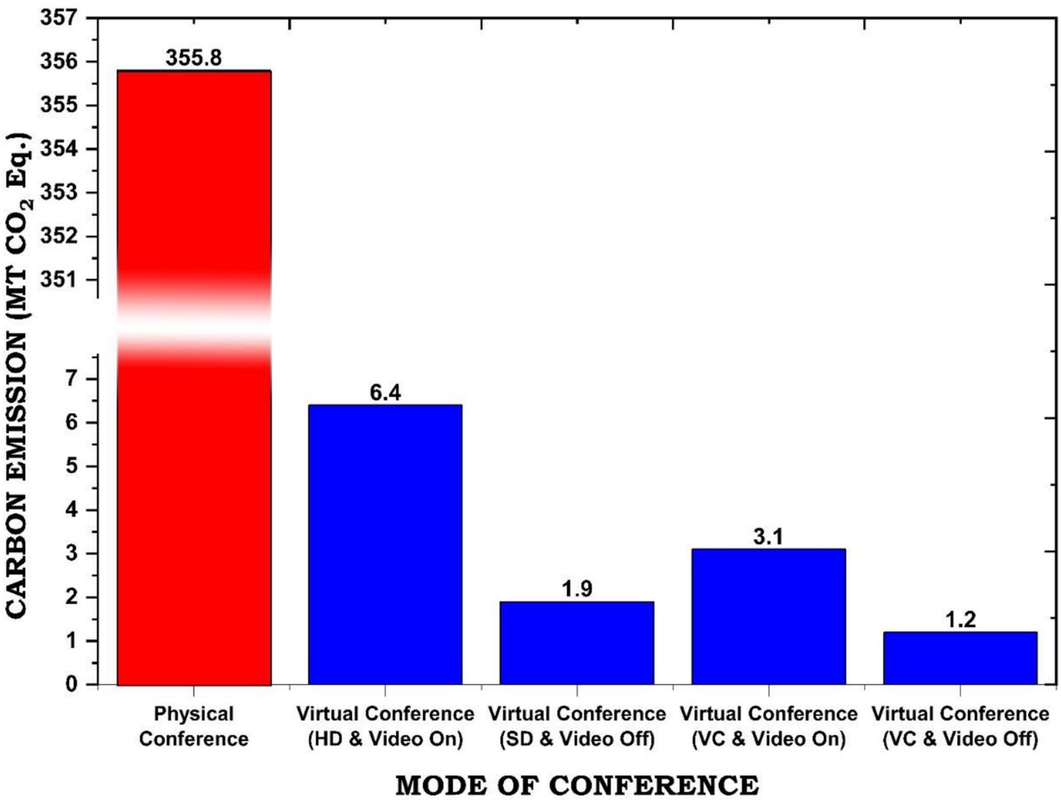


Figure 4. Comparison of CE from different modes of the conference: IAPSMCON 2021.

than the one reported for an academic conference in Europe (0.57 MT CO_2 Eq) (Neugebauer et al., 2020). Transportation of the delegates to attend the conference was the single most contributor toward the CE in our study, similar to the findings from existing literature (Kitamura et al., 2020; Neugebauer et al., 2020; Roberts & Godlee, 2007). The potential travel-related per capita emission was found to be 0.27 MT CO_2 Eq in our study, which is almost half that of reported from the 14th Congress of the European Association of Agricultural Economists (0.5 MT CO_2 Eq), annual meetings of the Societies for Pediatric Urology (0.6 MT CO_2 Eq) and ASAB (0.6 MT CO_2 Eq) (Desiere, 2016; Milford et al., 2020; Raby & Madden, 2021).

Van Ewijk et al. reported a travel-related per capita emission three times higher than our estimates, based on their analysis of three conferences from the USA, UK and South Korea (van Ewijk & Hoekman, 2021). Global average travel-related emissions for presenting a paper at conferences was estimated to be 0.8 MT CO_2 Eq. (Spinellis & Louridas, 2013). Wortzel et al. also assessed the travel related per capita CO_2 emission to be in the range of 1.19 to 1.61 MT CO_2 Eq for attending the American Psychiatric Association (APA) annual meets held in the USA (Wortzel et al., 2021). At the same time, the Fall Meeting of the American Geophysical Union reported 3 MT CO_2 Eq per capita for travel (Klöwer et al., 2020). The varied emission between the existing literature and our study might be due to differential methodology applied such as state-wise distance, and preferred mode of transport of the potential physical conference attendee was obtained in our study. Additionally, the emission factor for various modes of transport also varies between the countries. Certain conferences in the European countries coincide with the holidays of the attendee such that the carbon emission of the travel component was supposed to happen with or without the conference at that time. However, such practices are not prevalent in India, where the conference analyzed in the present study happened. Apart from the environmental advantages, virtual conference reduces the inequality posed by the physical conferences, for researchers worldwide in accessing the International conferences (Raby & Madden, 2021) (Table 3).

There was an overall reduction in the CE by about 250 million MT worldwide. However, the CE from the digital technologies increased by 450 MT since 2013 (Ferreboeuf, 2019). The need to assess the sector-wise contribution of the digital technologies is the need of the hour to ascertain their net impact. The CE reduction from the virtual conference should be prioritized, as the already rising digital carbon footprint, 8% annually (Itten et al., 2020) will only be further pushed up by the greater switch from physical to virtual mode of meetings and conferences. Though the virtual conferences significantly reduce the CE relative to physical mode, there is high scope for reducing the CE of the virtual systems. The reduction can be achieved by adopting digital sobriety as a policy in virtual conferences and meetings. Digital sobriety can be taken up at the

Table 3. Carbon emission of various conferences held across the world.

AUTHOR (YEAR OF PUBLICATION)	COUNTRY	CARBON EMISSION TOTAL MT CO_2 EQ (PHYSICAL)	CARBON EMISSION PER CAPITA MT CO_2 EQ (PHYSICAL)
Neugebauer et al. (2020)	Germany	455	0.57
Raby and Madden (2021)*	UK	234.7 (Physical) 1.1 (Virtual)	–
Desiere*	Slovenia	248-322	
Milford*	USA, Canada, and Czech Republic	–	0.31–0.93
van Ewijk*	USA	955	1.5
	UK	755	1.3
	South Korea	722	1.8
Wortzel et al. (2021)	USA	19,819–21,456	1.19–1.61

*Travel related carbon emission only.

organizational as well as the individual level. The live video streaming of the conference was the highest contributor towards the overall CE during the IAPSMCON 2021 (81.5%). The conference was streamed to the delegates, who formed the majority, and the session dignitaries participated through video conferencing (VC). However, exclusively using the VC platforms instead of streaming the conference to the delegates will reduce the CE by a range of 94 to 283 g (21.4%–64.3%) of CO_2 Eq emitted per hour per delegate during the conference (Faber, 2021). Such a modification would have reduced the CE emission in the IASPMCON 2021 by about 48%. Even within the VC, further CE reduction can be achieved by switching off the VC's self-videos by the attendees during the conference. It would reduce the carbon emission by about 151 g of CO_2 Eq per hour (96%) (Faber, 2021). Thus, if the virtual conference is conducted through VC wherein the delegates switch off their self-video and stream in SD, then a CE reduction of 98.6% can be achieved. This will have a considerable impact on the CE reduction from the global event industry, which is responsible for one-tenth of the global CO_2 emission (Tao et al., 2021). The organizers must intimate the above high-impact yet simple measures to the attendees to reduce their CE.

In general, health care conferences should acknowledge the role of the environment in health. The organizers should strive to conduct a carbon-neutral conference by preventing, mitigating, or offsetting the CE from various activities and materials consumed in the conference. Based on the digital sobriety action the delegates have undertaken, the green points can be awarded to them in their conference certification, which may be a motivating factor at the individual level.

The healthcare conference reports must have a section allocated towards the event's environmental impact and potential measures which were/are undertaken to make it a sustainable event. Sponsoring agencies for the conferences, especially public research bodies such as the councils of medical research, science and technology departments, may adopt a policy decision requiring the conference organizers to submit a self-assessed carbon impact assessment report for accessing the funds. Academic and research agencies may also earmark a specific proportion of funds for virtual and hybrid conferences in a given financial year. Certifying a conference as carbon neutral (*PAS 2060 The ideal standard for carbon neutrality*, n.d.) by adhering to the standards must be looked at the planning stage of the conference itself. The first step is to measure the potential carbon emission from the conference's activities, followed by adopting steps to reduce the CE by mitigation strategies and offsetting the unavoidable CE from the event (Künzli et al., 2013; *PAS* 2060 *The ideal standard for carbon neutrality*, n.d.). As a final step, the carbon neutrality shall be verified by self-validation and by a third party, who are the agencies accredited to certify (*PAS* 2060 *The ideal standard for carbon neutrality*, n.d.).

The downside of full-scale virtual meets is the lack of personal touch and social relationships during the physical conferences. Considering the multiple advantages of virtual conferences and the new normal post-COVID-19 pandemic, it will be prudent to strike a balance between virtual and physical modes of conferences in the long run. Following modalities can be worked out: (a) hybrid conferences wherein multiple physical nodes, preferably located in their state capitals, for the delegates to assemble in person, and these nodes are connected nationally with the organization hosting the conference, (b) conducting the physical and virtual conferences alternatively (Bousema et al., 2020; Wortzel et al., 2021) (c) one hub and node model, and (d) Multilateral Hub and Node (Fraser et al., 2017).

Study Limitations: The response rate among the registrants, which was used to provide data and assumptions to estimate the potential CE has the conference been held physically, was low. No data was collected on the stay preferences and food preferences of the registrants if they had attended the physical conference. Data on the carbon emission of the food consumed by the virtual attendees from their home/workplace was not factored in. In future conferences, efforts must be made to collect the above data from all the registrants to improve the accuracy of CE estimations from such activities. We could not get the model of the device used by the attendees for attending the virtual conference, which could have provided a more accurate CE of the device. Our findings could be improved in the future by collecting the information on the probable model of the device used, preferred quality of watching the proceedings (HD vs. SD), amount of time spent using laptops and smartphones per day and the average years of usage of the devices, from all the registered participants, during the registration process. It will help us to conduct the preliminary assessment of the potential carbon emission expected from the virtual conference. It will enable the organizers to devise the CE reduction strategies, which can be shared with the registrants before the beginning of the conference, and carbon offsetting actions that the event organizers can implement.

Conclusion

Climate change is a global phenomenon, and each sector needs to reduce its carbon emission. Public health conferences conducted in virtual mode drastically reduced carbon emission compared to the physical conference. Healthcare academic conferences in India and worldwide should strive to become carbon neutral by adopting the virtual mode of conferencing. Within that, digital sobriety should be the policy of action. Measures and policies to motivate the adoption of virtual conferencing and digital sobriety must be undertaken. Further research on the satisfaction levels of the delegates in terms of knowledge received, networking made, and collaboration achieved, and social relationships established/maintained in the virtual conferences must be compared with that of the physical conference to assess the impact of virtual mode on other facets.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

Ravindra Khaiwal https://orcid.org/0000-0002-1000-4844

Supplemental Material

Supplemental material for this article is available online.

REFERENCES

Abbott, A. (2020). Low-carbon, virtual science conference tries to recreate social buzz. *Nature*, 577, 13. https://doi.org/10.1038/d41586-019-03899-1

Bhawan, S., & Puram, R. K. (2018). *CO2 Baseline Database for the Indian Power Sector User*. Guide Government of India Ministry of Power Central Electricity Authority.

Bousema, T., Selvaraj, P., Djimde, A. A., Yakar, D., Hagedorn, B., Pratt, A., Barret, D., Whitfield, K., & Cohen, J. M. (2020). Reducing the carbon footprint of academic conferences: The example of the American Society of Tropical Medicine and Hygiene. *American Journal of Tropical Medicine and Hygiene*, 103, 1758–1761. https://doi.org/10.4269/ajtmh.20-1013

Cornell Hotel Sustainability Benchmarking Index – Greenview [WWW Document]. (n.d.). Retrieved February 16, 2022, from https://greenview.sg/services/chsb-index/ (accessed 2.16.22).

Desiere, S. (2016). The carbon footprint of academic conferences: Evidence from the 14th EAAE Congress in Slovenia. *EuroChoices*, 15, 56–61. https://doi.org/10.1111/1746-692x.12106

Duane, B., Lyne, A., Faulkner, T., Windram, J. D., Redington, A. N., Saget, S., Tretter, J. T., & McMahon, C. J. (2021). Webinars reduce the environmental footprint of pediatric cardiology conferences. *Cardiology in the Young*, 31, 1625–1632. https://doi.org/10.1017/S1047951121000718

Environment – Apple [WWW Document]. (n.d.). Retrieved from May 17, 2021, https://www.apple.com/environment/

Faber, G. (2021). A framework to estimate emissions from virtual conferences. *International Journal of Environmental Studies*, 4, 1–16. https://doi.org/10.1080/00207233.2020.1864190

Ferreboeuf, H. (2019). *LEAN ICT: Towards digital sobriety*. The Shift Project.

Flight Distance and Duration Calculator. (n.d.). Airport and Aviation Database – Great Circle Mapper [WWW Document]. Retrieved May 2, 2021, from https://www.greatcirclemapper.net/

Food Carbon Footprint Calculator – My Emissions [WWW Document]. (n.d.). Retrieved May 17, 2021, from https://myemissions.green/food-carbon-footprint-calculator/

Fraser, H., Soanes, K., Jones, S. A., Jones, C. S., & Malishev, M. (2017). The value of virtual conferencing for ecology and conservation. *Conservation Biology: The Journal of the Society for Conservation Biology*, 31, 540–546. https://doi.org/10.1111/cobi.12837

Gajjar, C., & Sheikh, A.; India GHG Program. (2015a). India specific road transport emission factors. *Transport Sector Emission Factor Methodologies*, 9–10. https://doi.org/10.13140/RG.2.2.28564.32646

Gajjar, C., & Sheikh, A. (2015b). India specific rail transport emission factors for passenger travel and Material Transport. *Transport Sector Emission Factor Methodologies*, 7. https://doi.org/10.13140/RG.2.2.25208.88328

Google Maps [WWW Document]. (n.d.). Retrieved May 2, 2021, from https://www.google.co.in/maps/dir///@30.5697679,76.4819447,10z/data=!4m2!4m1!3e0

Hotel Carbon Measurement Initiative (HCMI) [WWW Document]. (n.d.). Retrieved February 2, 2021, from https://sustainablehospitalityalliance.org/resource/hotel-carbon-measurement-initiative/

Hotel Footprinting Tool [WWW Document]. (n.d.). Retrieved March 22, 2021, from https://www.hotelfootprints.org/footprinting

India GHG Program. (2015). *India Specific Air Transport Emission Factors for Passenger Travel and Material Transport For Stakeholder Consultation*. Author.

Infographic: The Carbon Footprint of the Internet | ClimateCare [WWW Document]. (n.d.). Retrieved April 9, 2021, from https://www.climatecare.org/resources/news/infographic-carbon-footprint-internet/

Itten, R., Hischier, R., Andrae, A. S. G., Bieser, J. C. T., Cabernard, L., Falke, A., Ferreboeuf, H., Hilty, L. M., Keller, R. L., Lees-Perasso, E., Preist, C., & Stucki, M. (2020). Digital transformation—life cycle assessment of digital services, multifunctional devices and cloud computing. *The International Journal of Life Cycle Assessment*, 25, 2093–2098. https://doi.org/10.1007/s11367-020-01801-0

Jordan, C. J., & Palmer, A. A. (2020). Virtual meetings: A critical step to address climate change. *Science Advances*, 6, eabe5810. https://doi.org/10.1126/sciadv.abe5810

Kitamura, Y., Karkour, S., Ichisugi, Y., & Itsubo, N. (2020). Carbon footprint evaluation of the business event sector in Japan. *Sustainability*, 12, 5001. https://doi.org/10.3390/su12125001

Klöwer, M., Hopkins, D., Allen, M., & Higham, J. (2020). An analysis of ways to decarbonize conference travel after COVID-19. *Nature*, 583, 356–359. https://doi.org/10.1038/d41586-020-02057-2

Künzli, N., Ragettli, M. S., & Röösli, M. (2013). The vision of a green(er) scientific conference. *Environmental Health Perspectives*, 121, a236–a237. https://doi.org/10.1289/ehp.1307302

Life of a Mobile Phone in India [WWW Document]. (n.d.). Retrieved May 16, 2021, from https://www.livemint.com/Specials/dxyOahr9AIdGhcAkHjzzzI/Life-of-a-mobile-phone-in-india.html

MBiT Index 2021 | Nokia [WWW Document]. (n.d.). Retrieved May 16, 2021, from https://www.nokia.com/about-us/company/worldwide-presence/india/mbit-index-2021/

Milford, K., Rickard, M., Chua, M., Tomczyk, K., Gatley-Dewing, A., & Lorenzo, A. J. (2020). 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. *Journal of Pediatric Surgery*, 56, 1312–1316. https://doi.org/10.1016/j.jpedsurg.2020.07.013

Neugebauer, S., Bolz, M., Mankaa, R., & Traverso, M. (2020). How sustainable are sustainability conferences? – Comprehensive Life Cycle Assessment of an international conference series in Europe. *Journal of Cleaner Production*, 242, 118516. https://doi.org/10.1016/j.jclepro.2019.118516

New Uses for Old Phones: Upcycling the Rotary Dial Phone in the Age of the Smartphone – OCAD University Open Research Repository [WWW Document]. (n.d.). Retrieved May 16, 2021, from http://openresearch.ocadu.ca/id/eprint/224/.

Obringer, R., Rachunok, B., Maia-Silva, D., Arbabzadeh, M., Nateghi, R., & Madani, K. (2021). The overlooked environmental footprint of increasing Internet use. *Resources, Conservation and Recycling*, 167, 105389. https://doi.org/10.1016/j.resconrec.2020.105389

Our Data – My Emissions [WWW Document]. (n.d.). Retrieved February 16, 2022, from https://myemissions.green/our-data/

PAS 2060 The Ideal Standard for Carbon Neutrality. (n.d.). https://info.eco-act.com/hubfs/0%20-20Downloads/PAS%202060/PAS%202060%20factsheet%20EN.pdf

Raby, C. L., & Madden, J. R. (2021). Moving academic conferences online: Aids and barriers to delegate participation. *Ecology and Evolution*, 11, 3646–3655. https://doi.org/10.1002/ece3.7376

Roberts, I., & Godlee, F. (2007). Reducing the carbon footprint of medical conferences. *BMJ*, 334, 324–325. https://doi.org/10.1136/bmj.39125.468171.80

Spinellis, D., & Louridas, P. (2013). The carbon footprint of conference papers. *PLoS One*, 8, e66508. https://doi.org/10.1371/journal.pone.0066508

Tao, Y., Steckel, D., Klemeš, J. J., & You, F. (2021). Trend towards virtual and hybrid conferences may Be an effective climate change mitigation strategy. *Nature Communications*, 12, 7324–7414. https://doi.org/10.1038/s41467-021-27251-2

The Carbon Brief Profile: India [WWW Document]. (n.d.). Retrieved June 1, 2021, from https://www.carbonbrief.org/the-carbon-brief-profile-india.

The Most Popular iPhones – 2020 [WWW Document]. (n.d.). Retrieved May 17, 2021, from https://deviceatlas.com/blog/most-popular-iphones.

van Ewijk, S., & Hoekman, P. (2021). Emission reduction potentials for academic conference travel. *Journal of Industrial Ecology*, 25, 778–788. https://doi.org/10.1111/jiec.13079

What's the Carbon Footprint of Your Website? | Climate Protection | RESET.org [WWW Document]. (n.d.). Retrieved May 8, 2021, from https://en.reset.org/blog/whats-carbon-footprint-your-website-01162020

Wortzel, J. R., Stashevsky, A., Wortzel, J. D., Mark, B., Lewis, J., & Haase, E. (2021). Estimation of the carbon footprint associated with attendees of the American Psychiatric Association annual meeting. *JAMA Network Open*, 4, e2035641. https://doi.org/10.1001/jamanetworkopen.2020.35641