*Supplementary Information*

**Beyond the carbon footprint: Virtual conferences increase equity, diversity, and inclusion.**

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**Oral Sessions**

Oral sessions for analyzed conferences were either livestreamed or pre-recorded and all released at a specified time. POM 2 oral presentations were livestreamed via a single Webex session at 20 – 30 minutes intervals. While audience members could not share audio or video, they could submit questions via the zoom messenger feature. The speaker answered as many questions as possible at the end of the talk via zoom video stream, and then addressed the remaining questions via direct message to the question-asker. The format lacked a conversational element between the speaker and the audience, but was time efficient and averted technical difficulties. 2020 virtual NAMS and AAS talks were similarly livestreamed via zoom webinars. The NAMS talks took place at 20-minute intervals in five parallel zoom room sessions with only a 20-minute midday break and no buffer time between talks. 2020 Virtual NAMS Webinar attendance data indicated that generally only between 50% and 70% of registrants were attending the sessions at any given time and clear drops in attendance at 20-minute intervals showed that attendees were transitioning to other sessions between talks (**Figure S9**). Attendance in two rooms was disproportionately high relative to other rooms at some points, and the rates of transition between specific rooms were relatively high at other times, indicating the importance of not scheduling popular sessions in parallel. Some respondents to surveys distributed to 2020 virtual NAMS participants after the conference requested a longer conference with fewer parallel sessions to alleviate this issue. Conversely, the rate of transitions between rooms was spread evenly on the final day of the conference, indicating well balanced sessions. Attendance was relatively low for speakers that immediately followed the lunch break, indicating that the attendees needed a longer break. As the sessions were paced quickly and held in the middle of the day US time, it ensured that the talks took place at reasonable times for most other global attendees. However, the pace was difficult to maintain at times and parallel sessions occasionally failed to meet the tight schedule and were not in sync. Consequently, audience members felt at times that they could not take advantage of easy transitions to attend different talks. “Oral Session Scheduling” comments were the second most common response type to a post-conference survey question asking about areas of improvement for virtual NAMS:

“It might be better if the schedule is loosened up with some buffer time of 5 minutes between talks, giving more time for questions and for people to switch between sessions. Whenever a session went a bit long, after switching to another session the next talk may have already started. Alternately, you would have to leave early to be on time to the other session. Also, the break time between morning and afternoon sessions of only 20 minutes should probably be increased, so people planning to attend oral sessions at every time slot (for the whole day) have more time to eat lunch or organize their notes and prepare for the afternoon sessions.” – NAMS survey respondent

2020 virtual NAMS oral session audience members could not share audio or video, but could submit questions throughout the presentation via the zoom messenger, or could utilize the “raise hand” feature within zoom to indicate that they had a question. At the end of the talk, the question-askers were “promoted” and given video and audio sharing capabilities to ask and discuss their question with the presenter via the video livestream. This Q&A format inevitably introduced some delays and technical issues, but facilitated discussion. Oral sessions were generally successful, and were the most common answer to the survey question of “what worked well” at the 2020 virtual NAMS conference:

“Oral presentation to broader audience is quite achievable through remote audio video connection. It is also very easy to switch rooms between each parallel session to listen interested talks, which is not that much possible for in-person conference. Presenter's voice and slides are better heard and viewed through online meeting.” – NAMS survey respondent

2020 virtual ICLR pre-recorded oral sessions and released the videos at the start of the conference on their virtual platform. A live Q&A session was held for each keynote speaker after the video had been available for some time, where a moderator asked the speaker questions that were collected and up-voted via a messenger feature throughout the conference. Live Q&A session attendees could also “raise their hand” to ask and discuss questions live via the video stream. This oral session format averted technical difficulties with live-streaming talks while maintaining a discussion-oriented atmosphere during the Q&A session. The live Q&A sessions were recorded and made available indefinitely along with the pre-recorded presentations, eliciting persistent viewing after the conference ended.

Overall, currently available virtual environments are effective at delivering oral presentations and Q&A sessions. They were popular among attendees, with 43% of NAMS survey respondents and 74% of POM 2 survey respondents indicating that they preferred the virtual format for oral sessions over the in-person format (**Figure S10 and S11**).

**Posters**

Virtual platforms were successful at delivering poster content to viewers, but creating an interactive virtual poster experience remains a challenge. POM 1 & 2 hosted twitter poster sessions where authors filled out a provided poster template and published the finished posters on twitter. Presenters could then discuss content and answer questions from poster viewers via comment sections. This format effectively expanded the typical poster audience, with the posters remaining available indefinitely, and some POM 1 posters reaching 4000 views 1. While in-person interaction was not accommodated, the social media environment allowed attendees to continue engaging in the week following the conference, and allowed some to form lasting networks:

“The twitter poster session is a great initiative to grow the photonics community on twitter. I feel it also creates a long-lasting network between the people who presented posters as they can immediately form a connection.” – POM 2 survey respondent

However, some POM survey respondents indicated that it would have been beneficial to have provided a central page with a listing of posters for more efficient browsing. POM 2 also experimented with hosting Mozilla Hubs Virtual Reality Poster Sessions (MHVRPS), for up to 15 participants. In MHVRPS, participants used an avatar to move through a virtual room with posters projected on the walls. Participants could speak with other avatars using an audio stream, with the volume of avatar voices proportional to the distance between the avatars to simulate a real-life experience. The format was effective at simulating a conversational environment, but was only applied for a small number of posters and people, and would need to be scaled to fully meet the needs of a conference. NAMS and AAS employed the iPoster platform to host virtual posters filled out by participants using a distributed template. The NAMS posters were made available for viewing from a few days before the conference and up to a week after the conference. Live NAMS poster sessions were scheduled where poster viewers could interact with the poster presenters using either the iPoster messaging feature or by entering the zoom room assigned to each poster for face-to-face interaction with the presenter. The iPoster format expanded the typical audience for NAMS posters, with posters logging on average 142 views, and several posters logging over 700 views (**Figure S13**). Additionally, survey respondents indicated that this format was effective at distributing content:

“Interacting with the posters themselves was very user-friendly. I spent more time looking at posters than I normally would at a conference and it was easier to find ones I was interested in.” – NAMS survey respondent

Despite the high view counts, the virtual environment did not give presenters a sense of how many attendees were viewing their posters. Survey respondents indicated that some presenters felt discouraged and thought the virtual poster session was not effective at facilitating social interaction, leaving many presenters feeling isolated. This highlights a pervasive issue with virtual poster sessions, as the conversational nature of legacy poster sessions is difficult to recreate in a virtual environment.

“…the interactivity during the live sessions didn't work at all. I had precisely zero chats, messages, or visits to my poster (I was not part of the competition), and am not sure whether it got any visibility to the attendees. It may work better if attendees can schedule appointments with poster authors in advance. That way the authors aren't stuck in empty Zoom rooms missing out on networking.” – NAMS survey respondent

ICLR replaced posters with 5-minute pre-recorded presentations that were posted along with an abstract, paper, code, and reviews on a single page. Authors were also available for live video chat during two separate Q&A sessions scheduled to accommodate participants from different time zones. The 5-minute video presentations were high quality and the format was effective at conveying the main message of the paper to the viewer. However, many poster presenters felt isolated and did not know how many attendees were viewing their presentations. Additionally, participants were reluctant to enter live Q&A sessions as they felt the need to be well informed on the material should they be the only participant in the room with the presenter 2.

Overall, virtual poster sessions environments are less developed than virtual oral session environments and will be a primary target of future innovation. Virtual posters were less popular with conference participants and 85% of NAMS survey respondents and 43% of POM 2 survey respondents indicated that they preferred in-person poster sessions to virtual poster sessions (**Figure S10 and S11**).

**Networking**

Virtual conference platforms struggle to facilitate spontaneous social interaction and networking, but significant attention is being devoted to innovative new strategies for addressing this deficiency. While the incorporation of twitter in POMs instigated a significant amount of informal interaction, survey respondents indicated feelings of isolation:

“I have not talked to a single participant of the POMs – making new connections is not straightforward. I don’t even know who is there, other than the speakers.” – POM 2 survey respondent

The 2020 virtual NAMS conference attempted to facilitate the need for casual social interaction with “Virtual Hallways”, which comprised several zoom rooms that attendees could join to interact with other participants outside of the scheduled oral and poster sessions. Virtual Hallways were moderated by volunteers who could place groups of attendees in breakout rooms upon request. The virtual hallways were popular among some survey respondents who indicated having meaningful interactions via this networking option. However, surveys indicated that participants thought these interactions could feel inauthentic:

“One of the biggest consequences of being remote was the inability to casually chat with new people. Every interaction had to be directly organize, or in a large group (the large rooms).” -NAMS survey respondent

To address this issue, many survey respondents recommended that organizers provide full attendee lists as well as a platform “map” to indicate where particular attendees are located within the virtual environment at a particular time. Survey respondents also requested a central messaging feature and the ability to form their own breakout rooms for private interaction. 2020 virtual ICLR utilized a central chat feature and successfully encouraged participants to organize and host virtual meetups, resulting in 29 socials throughout the conference. However, the geographic reach of the socials was limited and the range of topics covered by the socials was narrow 2. Future conferences should strive to make these socials more global and inclusive.

Despite efforts by organizers, current methods for facilitating virtual networking are inadequate and will require further development and testing with future virtual events. Previous efforts show promise but were unpopular with attendees as 96% of NAMS survey respondents and 75% of POM 2 survey respondents indicated that they preferred in-person networking to virtual networking (**Figure S10 and S11**).

**Innovations/Platforms**

The COVID-19 pandemic has given rise to a burgeoning economy of commercial and open source technology designed to deliver virtual conferences. Many of these options have been employed to host 2020 virtual conferences. Organizers of the 2020 virtual ICLR conducted their conference using MiniConf, a virtual conference platform that they built themselves. MiniConf is designed to manage papers, schedules, and speakers for a virtual academic conference 3 and is available for public use here: *http://mini-conf.org*. Since the 2020 virtual ICLR, MiniConf has been used to host academic conferences covering a variety of fields. The Neuromatch conference used a virtual platform to facilitate 15-minute one-on-one networking sessions between attendees by algorithmically matching key words from their research abstracts 4. Organizers have also experimented with schedule designs to better accommodate global communities. The 2020 virtual ICLR followed an asynchronous schedule that could be engaged at a time that suited each participant. Pre-recorded presentations accommodated all time zones, and several live Q&A sessions were scheduled at different times for each presentation, so as to facilitate live interaction for participants from all regions. POM accommodated its global community by scheduling separate synchronous events, with POM 1 taking place during the day in North America and POM 2 occurring during hours that were convenient for Europe and the East. POM 1, which took place prior to the pandemic, also incorporated numerous hubs around the globe, where scientists could congregate for in-person interaction with local participants, while still engaging with the global community.

**Organizational Recommendations**

Cost of attendance to in-person conferences is more expensive for international participants and is especially restrictive to scientists from countries with less spending power. Consequently, conferences should consider assigning region-specific registration fees to accommodate scientists from historically marginalized countries. Organizers could also consider holding conferences in places such as Africa, as the cost of attendance would be lower and more inclusive of African scientists. However, the increased international travel created by forcing the large American contingent to travel overseas makes these events far less environmentally sustainable. This was demonstrated by the hypothetical 2020 ICLR in Ethiopia, which would have had an average attendee footprint of 3.39 tonnes CO2e, far greater than the historical average attendee footprint of historical ICLRs held in North America (1.49 tonnes CO2e). The high cost of attendance to in-person conferences also excludes persons from non-research-intensive institutions. To address this, conference organizers could also offer lower registration fees to attendees who are paying out-of-pocket instead of with grants. Organizers should also consider adopting a hybrid conference format such as that employed for POM 1. The hybrid format, comprised of numerous regional hubs spread around the globe participating in virtual sessions, maintains the advantages of both the virtual and in-person conference formats. Attendees have the option to avoid extensive travel and interact in-person with local community members, while consuming scientific content from the global community through virtual platforms that have proven effective at disseminating scientific knowledge. Alternatively, participants could still have the option to travel to an on-site location for a fully in-person conference experience at a greater cost.

Virtual environments are most effective at delivering oral content, and less effective at facilitating poster sessions and social networking. Consequently, it is recommended that organizers employ oral presentations as much as possible. Conference organizers and respondents to the 2020 virtual NAMS surveys agree that the plenary session on the first day was enjoyable and that convening the virtual conference for a plenary talk at the start each day of a multi-day conference would make the event more cohesive. Plenary presenters would also be easy to recruit considering the large audiences that virtual conferences attract. It is also important to ensure that presenters are familiar with the conference platform so as to avoid technical difficulties during the event. Live presenters should be required to attend a practice session prior to the virtual conference to ensure that they can successfully use the platform to present their work. If oral presentations are held live at scheduled times, it is especially important that the sessions strictly follow the schedule. Conference participants state that the ability to seamlessly move between parallel sessions is a major advantage of the virtual format, but this advantage is negated if the talks do not take place at the scheduled timeslots. Survey attendees also requested more than the one 20-min lunch break scheduled during the 2020 virtual NAMS conference, and attendance was low immediately following the lunch break, indicating the importance of allowing enough time during this midday break. Buffer time should also be scheduled between sessions and individual talks to allow flexibility, such as potentially leaving an open slot at the end of each session for a talk that had to be aborted due to technical difficulties. It could also be beneficial to instead use a virtual platform to release pre-recorded presentations and then hold live Q&A sessions after the recordings have been released. Chat features are a more efficient method for collecting and asking questions during a Q&A session, but asking questions via video chat does more to facilitate discussion.

While virtual posters can effectively deliver large amounts of content to broad audiences, interactive poster sessions are challenging to administer virtually. Organizers could consider replacing legacy poster sessions with pre-recorded oral presentations and then scheduling live Q&A sessions for questions collected via a chat feature throughout the conference or asked live by participants.

Facilitating networking is also challenging with a virtual environment, although significant attention is being devoted to developing software and virtual reality technology to address this shortcoming. A central messaging feature as well as a list of participants and their current locations within the virtual environment could help to accommodate informal social interaction. Giving attendees the ability to form their own breakout rooms would also be helpful, as informal social interaction is difficult via video chat in large groups. Most importantly, scientific communities should continue to develop and test innovative virtual conference solutions and share their findings, so virtual conferences can continue to get better for everyone.

**Table S1 |** Average cost of attendance per person calculated by converting one-way flight costs to round trip costs using either a factor of 2 or 1.5 for historical in-person, hypothetical 2020 in-person and 2020 virtual ICLR, AAS, and NAMS conferences.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Average Cost per Person (USD) | Round trip cost = one-way cost \* 2 | | |  | Round trip cost = one-way cost \* 1.5 | | |
| ICLR | AAS | NAMS |  | ICLR | AAS | NAMS |
| 2015 | - | - | $2,183 |  | - | - | $1,947 |
| 2016 | - | $1,973 | $2,774 |  | - | $1,789 | $2,436 |
| 2017 | - | $1,820 | - |  | - | $1,639 | - |
| 2018 | $3,224 | $1,883 | $1,895 |  | $2,909 | $1,715 | $1,671 |
| 2019 | $2,466 | $1,857 | $2,122 |  | $2,126 | $1,677 | $1,899 |
| Hypothetical 2020 In-person | $3,445 | $1,879 | $2,219 |  | $2,838 | $1,678 | $1,934 |
| 2020 Virtual | $74 | $162 | $72 |  | $74 | $162 | $72 |
| Historical Average | $2,795 | $1,885 | $2,215 |  | $2,466 | $1,707 | $1,965 |
| Percent Change in Virtual Conference Cost vs. Previous Historical Conferences | -97% | -91% | -97% |  | -97% | -91% | -96% |
| 2020 Virtual Conference Cost as Percent of Hypothetical 2020 In-person Conference Cost | 2.1% | 8.6% | 3.2% |  | 2.6% | 9.6% | 3.7% |

**Table S2 |** Total number of attendees, average cost of attendance, and percent difference in cost of attendance versus the United States for each region to historical in-person NAMS conferences and a hypothetical 2020 NAMS conference at the originally planned on-site location with the 2020 virtual NAMS delegation. \*Regions do not add up to total as some attendee origins are unknown and not included as a subsection in this table.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Region | Data | 2015 | 2016 | 2018 | 2019 | 2020 | 2015-2019 Average |
| Africa | Number of Attendees | 2 | 1 | 0 | 2 | 0 | 1.25 |
| Average Attendee Cost (USD) | 3995 | 6418 | - | 4692 | - | 4758 |
| % Cost Diff vs. USA | 131% | 179% | - | 182% | - | 174% |
| Asia | Number of Attendees | 38 | 49 | 39 | 44 | 16 | 42.5 |
| Average Attendee Cost (USD) | 4439 | 4139 | 4036 | 4414 | 4178 | 4254 |
| % Cost Diff vs. USA | 157% | 80% | 193% | 166% | 125% | 145% |
| Europe | Number of Attendees | 22 | 17 | 26 | 42 | 54 | 26.75 |
| Average Attendee Cost (USD) | 3112 | 4074 | 3130 | 3290 | 3535 | 3339 |
| % Cost Diff vs. USA | 80% | 77% | 128% | 98% | 90% | 92% |
| Middle East | Number of Attendees | 28 | 20 | 21 | 15 | 37 | 21 |
| Average Attendee Cost (USD) | 3884 | 4308 | 3713 | 3849 | 4231 | 3936 |
| % Cost Diff vs. USA | 125% | 88% | 170% | 132% | 127% | 127% |
| Oceania | Number of Attendees | 2 | 4 | 3 | 5 | 4 | 3.5 |
| Average Attendee Cost (USD) | 4924 | 4701 | 5451 | 5709 | 4022 | 5253 |
| % Cost Diff vs. USA | 185% | 105% | 296% | 244% | 116% | 203% |
| Other Americas | Number of Attendees | 10 | 9 | 16 | 45 | 24 | 20 |
| Average Attendee Cost (USD) | 1974 | 2137 | 1878 | 1775 | 2009 | 1861 |
| % Cost Diff vs. USA | 14% | -7% | 36% | 7% | 8% | 7% |
| USA | Number of Attendees | 345 | 257 | 310 | 394 | 500 | 326.5 |
| Average Attendee Cost (USD) | 1726 | 2297 | 1376 | 1661 | 1860 | 1736 |
| % Cost Diff vs. USA | - | - | - | - | - | - |
| Total | Number of Attendees | 456 | 362 | 428 | 553 | 635 | 450 |
| Average Attendee Cost (USD) | 2183 | 2774 | 1895 | 2122 | 2219 | 2215 |
| % Cost Diff vs. USA | 27% | 21% | 38% | 28% | 19% | 28% |

**Table S3 |** Number of countries represented, total attendees, and total attendees from the conference region at historically in-person turned virtual conferences. Conference region for historically in-person conferences is defined as the United States for AAS and NAMS (All in-person AAS and NAMS conferences were held in the United States) and North America for ICLR (All in-person ICLRs were held in United States or Canada).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Conference | Conference Attendance | | |  | Number of Countries Represented | | |
| ICLR | AAS | NAMS |  | ICLR | AAS | NAMS |
| 2015 | - | - | 456 |  | - | - | 23 |
| 2016 | - | 727 | 362 |  | - | 20 | 19 |
| 2017 | - | 615 | - |  | - | 20 | - |
| 2018 | 1985 | 740 | 428 |  | 39 | 18 | 24 |
| 2019 | 2584 | 753 | 553 |  | 51 | 18 | 27 |
| 2020 Virtual | 4980 | 1399 | 635 |  | 86 | 36 | 23 |
| Historical In-person Conference Average | 2284.5 | 708.8 | 449.8 |  | 45.0 | 19.0 | 23.3 |
| 2015-2018 Conference Average | 1985.0 | 694.0 | 415.3 |  | 39.0 | 19.3 | 22.0 |
| 2020 Virtual Conference Attendance Percent Change vs. Historical Average | 118% | 97% | 41% |  | 91% | 89% | -1% |
| Historical In-person Conference Average Attendance from Conference Region | 1488.0 | 607.8 | 326.5 |  | - | - | - |
| Historical In-person Conference Average Attendance from Conference Region as Percent of Total Attendance | 65% | 86% | 73% |  | - | - | - |

**Table S4 |** NAMS attendee gender as determined by a Gender API or through manual designation via author familiarity with community members or internet search of attendee name.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Type | Category | 2015 | 2016 | 2018 | 2019 | 2020 | 2015-2019 Avg |
| Manual | female | 118 | 87 | 107 | 152 | 193 | 116.0 |
| male | 302 | 251 | 310 | 391 | 423 | 313.5 |
| unknown | 36 | 24 | 11 | 10 | 19 | 20.3 |
| total | 456 | 362 | 428 | 553 | 635 | 449.8 |
| female % | 25.9% | 24.0% | 25.0% | 27.5% | 30.4% | 25.8% |
| male % | 66.2% | 69.3% | 72.4% | 70.7% | 66.6% | 69.7% |
| unknown % | 7.9% | 6.6% | 2.6% | 1.8% | 3.0% | 4.5% |
| API | female | 122 | 80 | 102 | 146 | 184 | 112.5 |
| male | 325 | 272 | 316 | 388 | 425 | 325.3 |
| unknown | 9 | 10 | 10 | 19 | 26 | 12.0 |
| total | 456 | 362 | 428 | 553 | 635 | 449.8 |
| female % | 26.8% | 22.1% | 23.8% | 26.4% | 29.0% | 25.0% |
| male % | 71.3% | 75.1% | 73.8% | 70.2% | 66.9% | 72.3% |
| unknown % | 2.0% | 2.8% | 2.3% | 3.4% | 4.1% | 2.7% |

**Table S5 |** Percent women in natural science and engineering fields for the countries represented in the delegations of historical in-person ICLRs.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Country | Conference | Value | 2018 | 2019 | Total Estimated Women |
| Argentina | ICLR | 33.07% | 2 | 0 | 0.66 |
| Australia | ICLR | 33.07% | 8 | 12 | 6.61 |
| Austria | ICLR | 33.07% | 3 | 5 | 2.65 |
| Belgium | ICLR | 33.07% | 2 | 9 | 3.64 |
| Brazil | ICLR | 33.07% | 4 | 1 | 1.65 |
| Burkina Faso | ICLR | 20.82% | 0 | 1 | 0.21 |
| Burundi | ICLR | 14.10% | 0 | 1 | 0.14 |
| Canada | ICLR | 33.07% | 320 | 205 | 173.64 |
| Chile | ICLR | 30.45% | 0 | 3 | 0.91 |
| China | ICLR | 33.07% | 71 | 76 | 48.62 |
| Colombia | ICLR | 35.38% | 0 | 1 | 0.35 |
| Czech Republic | ICLR | 20.78% | 3 | 3 | 1.25 |
| Denmark | ICLR | 33.07% | 4 | 5 | 2.98 |
| Estonia | ICLR | 40.91% | 0 | 1 | 0.41 |
| Ethiopia | ICLR | 15.41% | 0 | 1 | 0.15 |
| Finland | ICLR | 33.07% | 8 | 6 | 4.63 |
| France | ICLR | 33.07% | 41 | 59 | 33.07 |
| Germany | ICLR | 33.07% | 48 | 75 | 40.68 |
| Ghana | ICLR | 14.92% | 0 | 1 | 0.15 |
| Hungary | ICLR | 23.71% | 0 | 5 | 1.19 |
| India | ICLR | 11.92% | 16 | 11 | 3.22 |
| Iran | ICLR | 29.72% | 1 | 0 | 0.30 |
| Ireland | ICLR | 33.07% | 0 | 1 | 0.33 |
| Israel | ICLR | 33.07% | 31 | 26 | 18.85 |
| Italy | ICLR | 33.07% | 6 | 5 | 3.64 |
| Japan | ICLR | 33.07% | 64 | 62 | 41.67 |
| Latvia | ICLR | 46.44% | 0 | 1 | 0.46 |
| Lebanon | ICLR | 33.07% | 1 | 0 | 0.33 |
| Luxembourg | ICLR | 29.01% | 0 | 1 | 0.29 |
| Morocco | ICLR | 40.61% | 0 | 1 | 0.41 |
| Netherlands | ICLR | 24.09% | 25 | 28 | 12.77 |
| Nigeria | ICLR | 33.07% | 0 | 1 | 0.33 |
| North Korea | ICLR | 33.07% | 1 | 1 | 0.66 |
| Norway | ICLR | 33.07% | 3 | 9 | 3.97 |
| Poland | ICLR | 31.67% | 3 | 7 | 3.17 |
| Portugal | ICLR | 39.70% | 1 | 4 | 1.99 |
| Qatar | ICLR | 26.20% | 2 | 1 | 0.79 |
| Romania | ICLR | 45.90% | 1 | 0 | 0.46 |
| Russia | ICLR | 33.07% | 26 | 18 | 14.55 |
| Rwanda | ICLR | 21.36% | 0 | 1 | 0.21 |
| Saudi Arabia | ICLR | 33.07% | 2 | 2 | 1.32 |
| Singapore | ICLR | 33.07% | 7 | 8 | 4.96 |
| South Africa | ICLR | 33.07% | 5 | 1 | 1.98 |
| South Korea | ICLR | 33.07% | 65 | 103 | 55.56 |
| Spain | ICLR | 33.07% | 17 | 4 | 6.95 |
| Swaziland | ICLR | 33.07% | 1 | 0 | 0.33 |
| Sweden | ICLR | 33.07% | 11 | 6 | 5.62 |
| Switzerland | ICLR | 33.07% | 34 | 38 | 23.81 |
| Taiwan | ICLR | 33.07% | 18 | 11 | 9.59 |
| Turkey | ICLR | 30.69% | 2 | 1 | 0.92 |
| Uganda | ICLR | 24.66% | 0 | 3 | 0.74 |
| Ukraine | ICLR | 40.68% | 0 | 4 | 1.63 |
| United Arab Emirates | ICLR | 33.07% | 1 | 0 | 0.33 |
| United Kingdom | ICLR | 33.07% | 169 | 260 | 141.89 |
| Uruguay | ICLR | 47.18% | 0 | 1 | 0.47 |
| USA | ICLR | 34.28% | 958 | 1493 | 840.12 |
| Vietnam | ICLR | 33.07% | 0 | 1 | 0.33 |
|  |  |  |  | Women as % of Attendees to all Conferences | 33% |

**Table S6 |** Percent women in natural science and engineering fields for the countries represented in the delegations of historical in-person AAS conferences.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Country | Conference | Value | 2016 | 2017 | 2018 | 2019 | Total Estimated Women |
| Australia | AAS | 33.07% | 3 | 1 | 2 | 3 | 2.98 |
| Austria | AAS | 33.07% | 1 | 0 | 0 | 0 | 0.33 |
| Belgium | AAS | 33.07% | 0 | 1 | 0 | 1 | 0.66 |
| Canada | AAS | 33.07% | 4 | 7 | 5 | 6 | 7.28 |
| Chile | AAS | 30.45% | 1 | 1 | 1 | 0 | 0.91 |
| China | AAS | 33.07% | 3 | 7 | 0 | 4 | 4.63 |
| Colombia | AAS | 35.38% | 0 | 1 | 1 | 1 | 1.06 |
| Ethiopia | AAS | 15.41% | 1 | 0 | 1 | 0 | 0.31 |
| Finland | AAS | 33.07% | 1 | 1 | 0 | 0 | 0.66 |
| France | AAS | 33.07% | 2 | 3 | 1 | 1 | 2.32 |
| Germany | AAS | 33.07% | 5 | 4 | 6 | 5 | 6.61 |
| Ghana | AAS | 14.92% | 0 | 0 | 1 | 0 | 0.15 |
| Holy See (Vatican City) | AAS | 33.07% | 0 | 0 | 0 | 1 | 0.33 |
| Hungary | AAS | 23.71% | 0 | 1 | 1 | 0 | 0.47 |
| Iceland | AAS | 33.07% | 1 | 0 | 0 | 0 | 0.33 |
| India | AAS | 11.92% | 0 | 0 | 0 | 1 | 0.12 |
| Iraq | AAS | 43.06% | 0 | 0 | 0 | 1 | 0.43 |
| Israel | AAS | 33.07% | 1 | 0 | 0 | 0 | 0.33 |
| Italy | AAS | 33.07% | 1 | 0 | 1 | 0 | 0.66 |
| Japan | AAS | 33.07% | 1 | 1 | 2 | 3 | 2.32 |
| Mexico | AAS | 33.07% | 2 | 0 | 0 | 1 | 0.99 |
| Netherlands | AAS | 24.09% | 2 | 1 | 4 | 1 | 1.93 |
| Russia | AAS | 33.07% | 0 | 0 | 2 | 1 | 0.99 |
| Slovakia | AAS | 33.54% | 0 | 1 | 0 | 0 | 0.34 |
| South Africa | AAS | 33.07% | 0 | 1 | 1 | 0 | 0.66 |
| South Korea | AAS | 33.07% | 6 | 5 | 3 | 6 | 6.61 |
| Spain | AAS | 33.07% | 0 | 1 | 0 | 0 | 0.33 |
| Switzerland | AAS | 33.07% | 4 | 0 | 2 | 1 | 2.32 |
| Taiwan | AAS | 33.07% | 1 | 1 | 0 | 0 | 0.66 |
| United Kingdom | AAS | 33.07% | 5 | 4 | 5 | 10 | 7.94 |
| Unknown | AAS | 33.07% | 63 | 50 | 54 | 63 | 76.07 |
| Uruguay | AAS | 47.18% | 0 | 1 | 0 | 0 | 0.47 |
| USA | AAS | 34.28% | 619 | 522 | 647 | 643 | 833.26 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  | Women as % of Attendees to all Conferences | 34% |

**Table S7 |** Percent women in natural science and engineering fields for the countries represented in the delegations of historical in-person NAMS conferences.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Country | Conference | Value | 2015 | 2016 | 2018 | 2019 | Total Estimated Women | |
| Argentina | NAMS | 33.07% | 0 | 0 | 0 | 1 | | 0.33 | |
| Australia | NAMS | 33.07% | 2 | 4 | 3 | 5 | | 4.63 | |
| Austria | NAMS | 33.07% | 0 | 1 | 1 | 3 | | 1.65 | |
| Belgium | NAMS | 33.07% | 0 | 1 | 0 | 4 | | 1.65 | |
| Brazil | NAMS | 33.07% | 2 | 0 | 3 | 3 | | 2.65 | |
| Canada | NAMS | 33.07% | 8 | 9 | 13 | 41 | | 23.48 | |
| China | NAMS | 33.07% | 10 | 20 | 11 | 10 | | 16.87 | |
| Czech Republic | NAMS | 20.78% | 0 | 2 | 3 | 0 | | 1.04 | |
| Denmark | NAMS | 33.07% | 0 | 2 | 0 | 1 | | 0.99 | |
| France | NAMS | 33.07% | 1 | 2 | 3 | 3 | | 2.98 | |
| Germany | NAMS | 33.07% | 8 | 0 | 3 | 7 | | 5.95 | |
| Hungary | NAMS | 23.71% | 0 | 0 | 0 | 1 | | 0.24 | |
| India | NAMS | 11.92% | 0 | 0 | 1 | 0 | | 0.12 | |
| Israel | NAMS | 33.07% | 6 | 6 | 6 | 8 | | 8.60 | |
| Italy | NAMS | 33.07% | 4 | 3 | 4 | 4 | | 4.96 | |
| Japan | NAMS | 33.07% | 3 | 5 | 6 | 9 | | 7.61 | |
| Netherlands | NAMS | 24.09% | 2 | 0 | 3 | 6 | | 2.65 | |
| Norway | NAMS | 33.07% | 1 | 0 | 1 | 2 | | 1.32 | |
| Portugal | NAMS | 39.70% | 0 | 0 | 1 | 0 | | 0.40 | |
| Russia | NAMS | 33.07% | 0 | 0 | 0 | 2 | | 0.66 | |
| Saudi Arabia | NAMS | 33.07% | 19 | 14 | 14 | 6 | | 17.53 | |
| Singapore | NAMS | 33.07% | 11 | 10 | 5 | 11 | | 12.24 | |
| South Africa | NAMS | 33.07% | 1 | 1 | 0 | 2 | | 1.32 | |
| South Korea | NAMS | 33.07% | 14 | 14 | 14 | 10 | | 17.20 | |
| Spain | NAMS | 33.07% | 1 | 1 | 3 | 1 | | 1.98 | |
| Sweden | NAMS | 33.07% | 1 | 0 | 0 | 0 | | 0.33 | |
| Switzerland | NAMS | 33.07% | 2 | 2 | 2 | 2 | | 2.65 | |
| Taiwan | NAMS | 33.07% | 0 | 0 | 2 | 4 | | 1.98 | |
| Tunisia | NAMS | 33.07% | 1 | 0 | 0 | 0 | | 0.33 | |
| Turkey | NAMS | 30.69% | 1 | 0 | 1 | 0 | | 0.61 | |
| United Arab Emirates | NAMS | 33.07% | 2 | 0 | 0 | 1 | | 0.99 | |
| United Kingdom | NAMS | 33.07% | 2 | 3 | 2 | 6 | | 4.30 | |
| Unknown | NAMS | 33.07% | 9 | 5 | 13 | 6 | | 10.91 | |
| USA | NAMS | 34.28% | 345 | 257 | 310 | 394 | | 447.65 | |
|  |  |  |  |  |  | Women as % of Attendees to all Conferences | | 34% | |

**Table S8 |** Total carbon footprint of historically in-person turned virtual conferences presented as the total greenhouse gas footprint converted to CO2 equivalents (CO2e)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Conference Footprint (tonnes CO2e) | ICLR | AAS | NAMS | Total |
| 2015 | - | - | 520 | 520 |
| 2016 | - | 653 | 561 | 1213 |
| 2017 | - | 525 | - | 525 |
| 2018 | 2904 | 565 | 471 | 3940 |
| 2019 | 3915 | 625 | 624 | 5163 |
| Hypothetical 2020 In-person | 16858 | 1304 | 858 | 19021 |
| 2020 Virtual | 0.80 | 0.17 | 0.10 | 1.07 |
| Historical Average | 3410 | 592 | 544 | 4545 |
| Percent Change Most Recent In-person (2019) vs. Previous Historical Conferences | 35% | 8% | 21% | - |
| 2020 Virtual Conference Footprint as Percent of Hypothetical 2020 In-person Conference Footprint | 0.005% | 0.013% | 0.012% | - |

Table

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**Table S9 |** Analyzed historically in-person turned virtual conferences with listed historical years for which data is available, 2020 event dates and information on data sources and data types.



**Fig. S2 |** Cost and convenience were the most common reasons given by attendees for deciding to attend the 2020 virtual NAMS conference after not planning on attending the originally scheduled 2020 in-person NAMS conference.

**Fig. S1 |** A large percent of attendees to the virtual POM 1 and POM 2 were from NI>10 countries.



**Fig. S3 |** A larger percent of abstracts submitted to NAMS after the decision to move online came from female scientists compared to before the decision to move online.

**Fig. S4 |** A significant percent of 2020 virtual NAMS conference attendees were not planning on attending the originally scheduled 2020 in-person NAMS conference before it was moved online.



**Fig. S5 |** A large percent of attendees to the virtual POM 1 and POM 2 were students.



**Fig. S6 |** Percent makeup by job type was similar between the 2019 in-person AAS conference and the 2020 virtual AAS conference.

n = 26

n = 266

**Fig. S7 |** Large percentages of attendees to NAMS and POM 2 indicated that they foresaw networking/social and internet/tech issues as the greatest challenges in the online format.

**Fig. S8 |** Relative to other job types, a larger percentage of graduate and undergraduate students that submitted abstracts to the originally planned in-person 2020 NAMS conference elected to attend the virtual NAMS after the decision to move online.



**Fig. S9 |** Attendees in each oral session and total percent of registrants participating in oral sessions throughout the 2020 virtual NAMS conference.

**Fig. S11 |** The majority of POM 2 survey respondents indicated that they preferred the online format for oral sessions and poster sessions compared to the in-person format, while networking was less popular.

**Fig. S10 |** A significant portion of 2020 virtual NAMS survey respondents indicated that they preferred the online format for oral sessions compared to the in-person format, while online poster sessions and online networking were less popular.

**Fig. S12 |** 2020 virtual ICLR platform page views continued to accrue at a significant rate for months after the scheduled conference dates.

**Fig. S13 |** 2020 Virtual NAMS iPosters accrued high view counts, with the average poster receiving 142 views and the 10 most-viewed posters all accruing over 350 views.

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