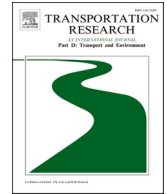




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Conference air travel's relevance and ways to reduce it

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ABSTRACT

Reducing emissions from air travel has become an important goal of academic institutions and conferences are a major reason for researchers' air travel. We conducted separate surveys with researchers at 17 academic institutions in Switzerland, Austria and Germany to examine perceptions of conference air travel and to assess opportunities for its reduction. The results indicate that air travel is deeply embedded in academia through cognitive norms and established conference practices. Although researchers stated that conferences serve important career purposes, such as networking, they acknowledge the importance of reducing air travel. The COVID-19 pandemic served as a window of opportunity to reduce air travel by switching to virtual conferences. Researchers stated that virtual conferences come with both benefits and challenges. Using the transport cultures framework, we identify opportunities for behavioural change and provide concrete recommendations for reducing conference air travel based on long-term changes in practices, material cultures, cognitive norms and policies.

1. Introduction

The aviation sector contributed up to 4 % to the earth's 1.2 °C anthropogenic warming until 2019 (Lee et al., 2021). Along with the sector's environmental unsustainability, air travel is associated with inequities (in terms of affordability, accessibility, etc.) and displays an uneven distribution (Hopkins, 2024). In 2018, only around 11 % of the world's population took a flight, and half of all passenger air travel emissions were attributed to the actions of 1 % of the world's population (Gössling and Humpe, 2020).

To achieve international climate goals, such as those defined in the Paris Agreement, air travel needs to be decarbonised. However, it is highly questionable whether technological solutions can curb emissions from aviation within the required time frame, as they currently face several obstacles. Energy efficiency gains from aircrafts are stagnating, while 'sustainable' and synthetic aviation fuels struggle with high life-cycle emissions, residual non-CO₂ effects, high energy demand, low technological maturity and pressure on natural resources (Nick and Thalmann, 2022; Sacchi et al., 2023). If air travel is not reduced substantially, the aviation sector will rely

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on carbon dioxide removal to achieve climate-neutral aviation (Brazzola et al., 2022), which, if deployed on a large scale, can lead to substantial environmental impacts and high energy demand (Jeswani et al., 2022). Thus, a substantial change in air travel behaviour to reduce aviation demand is needed (Sacchi et al., 2023).

Business travel comprises 17 % of aviation-related greenhouse gas (GHG) emissions (Müller, 2023). Academia contributes to this sector, with air travel comprising up to two-thirds of a university's GHG emissions (Ahonen et al., 2021; Arsenaault et al., 2019; Wynes and Donner, 2018). Academic researchers (henceforth, *researchers*) often perceive flying as being linked directly with research excellence, international recognition and, thus, academic career success (Hopkins et al., 2019; Nursey-Bray et al., 2019). However, researchers also have been called upon to reduce their air travel to limit their individual carbon footprints, serve as role models, remain credible and democratise access to knowledge (Attari et al., 2016; Le Quééré et al., 2015).

As part of the 'academic flying less movement' (Katz-Rosene and Pasek, 2023), a number of academic institutions have set ambitious net-zero GHG emission targets to be reached between 2025 and 2050 (Görlinger, 2023, p. 19). Thus, several universities – mainly in Western Europe, Australia, New Zealand and North America – have responded to increased external and internal pressures, implementing various measures to reduce academic air travel emissions (Kreil and Stauffacher, 2021; Müller, 2023; Kreil, 2019). However, challenges remain regarding systematic air travel data monitoring, leadership support, lack of monetary and human resources, organisational barriers and specifications as to who needs to act (Ahonen and Rask, 2024; Hoolohan et al., 2021; Kreil and Stauffacher, 2021; Müller, 2023). Furthermore, Müller (2023) highlighted the limitations of voluntary emission reduction measures.

Academic conferences (henceforth, *conferences*) are among researchers' main reasons for travelling (Lassen, 2006; Storme et al., 2013; Wynes and Donner, 2018), generating significant amounts of GHG emissions that can add up to three tonnes of CO₂-equivalent emissions per person (Klöwer et al., 2020). Epp et al. (2023) calculated that GHG emissions from a single conference with around 3,800 attendees 'are equivalent to the entire carbon footprint of 50,000 people in a low-income country (e.g., Uganda) over 1 year' (p. 3). Furthermore, scientific conferences as part of the overall meeting industry are a multibillion business with largely public funding (Rowe, 2019). Nevertheless, conferences are perceived as important venues where researchers disseminate knowledge, build networks and initiate collaborations, functioning as an integral part of academic work (Hauss, 2021; Rowe, 2018). However, as Rowe (2019) pointed out, despite the enormous cost of conferences, this perception is not based on solid scientific evidence.

In 2020, the COVID-19 pandemic (henceforth; *COVID-19*) led to an abrupt halt to air travel and an unforeseen shift towards virtual conferences. This served as a real-world case study through which to observe how academic air travel can be reduced and how many research activities, such as conferences, can be shifted to more sustainable formats (Moss et al., 2021). Virtual conferences in particular have been studied during this time, indicating that they substantially reduce not only GHG emissions, but also inequities, while increasing diversity due to higher accessibility (Doğan et al., 2023; Skiles et al., 2021; Tao et al., 2021).

Most of the extant studies on academic air travel reduction focussed on single cases, while studies on conference air travel mainly focussed on one specific conference. Hence, there is currently a lack of research providing a broader picture across institutions and countries. In this article, we combined data from surveys conducted among researchers from a variety of academic institutions (both universities and other research institutions), different scientific disciplines, and career stages in three German-speaking European countries to provide a more holistic view of the factors that shape and influence the reduction of conference air travel. More specifically, we examined the following research questions, focussing specifically on conferences:

RQI. What are researchers' opinions on (reducing) academic air travel, and what shapes them?

RQII. How do researchers perceive the significance of conferences?

RQIII. What are researchers' perceptions of alternatives to conference air travel, such as ground-based travel and virtual/hybrid conferences, and what shapes these perceptions?

To answer these questions, we analysed data collected through eight surveys conducted independently with researchers in different countries as part of three real-world projects that aim to reduce academic air travel: the Swiss ETH Zurich project, the Austrian Transflight project and the German FlyingLess project. These projects represent a major part of German-speaking Europe. The ETH Air Travel Project focusses on a single university, allowing for a detailed analysis over time, whereas Transflight and FlyingLess comprise a broad database encompassing 17 academic institutions in total, making it, to the best of our knowledge, the largest survey database on conference travel that has been analysed. By employing the transport cultures framework (Tseng et al., 2022a), this paper aims to identify opportunities for behavioural change and provide concrete recommendations on how to reduce conference air travel in academia.

2. Theoretical background

2.1. Academic air travel's embeddedness – The transport cultures framework

Air travel is embedded deeply in academia, viewed as contributing favourably to idea generation, efficiency, quality, research assessment metrics, recreation and status (Poggioli and Hoffman, 2022). More specifically, in Nursey-Bray et al.'s (2019) study, researchers stated that air travel was related directly to their career success, viewing it as necessary for their job. Thus, not only researchers' individual preferences, but also academia's structural conditions influence air travel behaviour.

Tseng et al. (2022a) used the transport cultures framework to examine academic air travel behaviour and identify opportunities for reducing air travel. The transport cultures framework is based on the energy cultures framework (Stephenson et al., 2010) and aims to understand factors and interactions that influence transport behaviour and identify opportunities for behavioural change (Stephenson

et al., 2015a,b). At the centre of the transport cultures framework lies an actor's transport behaviour, which is shaped by three core elements: material culture, cognitive norms and practices (Stephenson et al., 2010, 2015a,b). In the case of academic air travel, material culture refers to assets and resources, such as information and communication technology and transportation infrastructure. Cognitive norms comprise personal or social beliefs, expectations within the scientific community and perceptions about how to cultivate a successful academic career. Practices refer to activities and processes that either are routinized or irregular, such as holding conferences. Furthermore, external moderators, over which the actor has no agency, also influence air travel behaviour. These moderators, such as family commitments and institutional support, may influence one or more elements, thereby locking in behavioural patterns or driving behavioural change (Tseng et al., 2022b).

This framework highlights the interactivity between these three elements, making it apparent that change in one element can lead to change in others. Therefore, wider systemic change towards reducing academic air travel can originate from changes in one or several elements (Stephenson et al., 2015a,b). In this article, we will apply the transport cultures framework to the case of conference air travel by relating our results to the three different elements and applying the framework to identify recommendations for behavioural change in conference air travel (see Section 5.1).

2.2. Conference practices, purposes and long-term goals

The transport cultures framework (Tseng et al., 2022b) emphasises that conference organisation and attendance practices are an important element in shaping researchers' air travel behaviour. The practice of conference attendance can be divided further into several more specific practices. For researchers, attending conferences typically involves travelling to the conference location, giving presentations, discussing their work with colleagues, receiving feedback, listening to talks, attending conference dinners, socialising with other researchers in the community and sightseeing (Etzion et al., 2022; Rowe, 2018).

These conference practices serve several different purposes, such as exchanging information and knowledge, gaining new skills, forming and maintaining networks, initiating collaborations, discovering job opportunities and taking a break from daily routines (Edelheim et al., 2018; Etzion et al., 2022; Hauss, 2021; Oester et al., 2017). The opportunity to form and maintain networks at conferences has been highlighted as particularly important, especially for conference attendees' satisfaction with the conference (Hauss, 2021; Jung and Tanford, 2017; Mair et al., 2018). Edelheim et al. (2018) concluded that 'the networks one creates at conferences can open more doors in careers than any one "highly ranked journal" publication can' (p. 105).

Taking a broader perspective, fulfilling these immediate conference purposes serves to achieve several long-term goals, such as forming professional identities, gaining visibility, earning a reputation (for individuals as well as departments and universities), receiving funding and advancing one's academic career (Edelheim et al., 2018; Hansen and Pedersen, 2018; Hauss, 2021; Oester et al., 2017; Rowe, 2018). Lomnitz (1983) and Hansen et al. (2020) have argued that conferences ultimately serve to gain recognition for researchers. To achieve this recognition, according to Hansen et al.'s (2020) credibility cycle, different forms of credibility – such as presentations, academic networks, scholarly output and grants – can be invested and converted into each other during conferences.

2.3. Strategies to reduce conference air travel

The avoid-shift-improve framework can be used to conceptualise how emissions related to conference air travel can be reduced by (i) avoiding flights, such as by reducing in-person conference attendance or switching to virtual attendance; (ii) shifting to alternative, ground-based transportation modes to attend conferences and/or (iii) improving aviation technology to emit fewer emissions (Bakker et al., 2014). In the present study, we focussed on avoiding and shifting strategies, which can be achieved through behavioural changes on the demand side on individual, collective or institutional levels.

To reduce conference air travel, various reduction measures were compiled as part of two air travel projects in Switzerland and Germany (Kreil, 2020a; Görlinger, 2023). Proposed measures for shifting behaviour include: (i) choosing conference locations that are in close proximity to the majority of attendees, thereby minimising air travel emissions (Jäckle, 2019; Klöwer et al., 2020); (ii) promoting and providing booking support and financial incentives to shift to ground-based travel for short and medium distances (Jäckle, 2019; Köhler et al., 2022; van der Vliet et al., 2024; Van Ewijk and Hoekman, 2021) and (iii) attending more regional conferences (Köhler et al., 2022). Measures to avoid air travel include (i) changing from annual to biennial conference series and (ii) alternating between virtual and in-person conference formats (Klöwer et al., 2020).

Virtual and hybrid conferences make particularly significant impacts, as they can replace long-distance flights, thereby reducing conferences' carbon footprints by more than 90 % in fully virtual settings (Tao et al., 2021). Hybrid conferences come in a variety of forms and, depending on the format, can reduce air travel emissions by up to 60–80 % compared with in-person conferences (Cavallin Toscani et al., 2023; Klöwer et al., 2020; Van Ewijk and Hoekman, 2021). The literature has suggested holding hybrid conferences in one central location, allowing for additional virtual participation (e.g., for those attendees who would need to travel the furthest), or in multiple hubs by connecting virtually between conference hubs (Charlton-Perez et al., 2021; Moss et al., 2022; Van Ewijk and Hoekman, 2021).

3. Methods and data

To answer our research questions, we draw on empirical data collected through online surveys. The surveys were conducted as part of three independent projects focussing (partly or exclusively) on academic air travel: the ETH Zurich Air Travel Project,¹ the Transflight² project, and the FlyingLess³ project. All projects were developed separately, but have enough similarities to offer the potential for cross-case comparisons as they are similar in terms of context. The data from the eight surveys offers a unique opportunity to look for more generic patterns across countries and institutions in the German-speaking region of Europe. More information on the projects can be found in [Supplementary Material B](#).

In this article, we include selected quantitative results from surveys conducted with researchers of 17 German-speaking academic institutions as part of the three air travel projects in Switzerland, Austria, and Germany. Although the surveys focussed on questions about academic air travel in general, they also included questions on researchers' opinions on conference air travel, not related to specific conferences but to conferences in general. Furthermore, we present results from all three projects' open-ended survey questions that are important in explaining the quantitative variables presented and for drawing recommendations on how to reduce academic air travel. Example quotes – translated into English and corrected for grammar and syntax – are included for illustrative purposes. Although reports summarising results and papers analysing data from individual surveys have been published in part before ([Table 1](#)), this is the first comprehensive analysis of the eight surveys from all three projects that tackles the set of research questions posed in [Section 1](#).

All surveys were completed anonymously and voluntarily, without any compensation, in about 15 minutes. For this article, we restricted the sample to researchers (i.e., academic staff), although some surveys included students and/or administrative staff. We present only selected questions from the surveys (see [Supplementary Tables A1-A11](#) for an overview of the survey questions), all of which included questions related to academic air travel reduction. However, questions and response scales differ between surveys, although some variables were measured in a similar way in more than one survey. More details on the surveys (method, results) can be found in the reports and documents linked in [Table 1](#).

At ETH, four online surveys were conducted with scientific employees from 2020 to 2022 ([Table 1](#)), which mainly work in science, technology, engineering, and mathematics (STEM) fields given that ETH is a technical university. Invitations to two of the surveys were sent via email to all ETH professors (response rates = 26 % in 2020 and 20 % in 2021) by an ETH vice president, whereas invitations to the other two surveys were sent via email to all scientific staff at ETH without professorial titles (response rates = 5.77 % in 2020 and 6.3 % in 2022) by the scientific staff association. The surveys aimed to examine how ETH members perceive the air travel project, ETH members' opinions on academic air travel (reduction) and COVID-19's impact on academic air travel. Survey questions varied between the four surveys. The two conducted in 2020 focussed on ETH employees' reception of the air travel project and their attitudes towards academic air travel (reduction). The 2021 and 2022 surveys shifted the focus towards COVID-19's impact on academic air travel and ETH employees' opinions on virtual communication, while repeatedly examining respondents' attitudes towards academic air travel.

In the **Transflight** pre-project, an online survey was conducted in 2020 among all employees at the University of Graz (response rate: 11.5 %; [Table 1](#)). It focussed on factors shaping respondents' travel decisions, their willingness to reduce their professional air travel and their support for or rejection of several potential university policies to reduce emissions from academic air travel. In the main Transflight project, an online survey was conducted in 2022 among researchers at three other universities across Austria (response rates: 7 %, 10 %, and 14 %; two universities with a broad portfolio, one university of technology). This survey mainly focussed on experiences with virtual formats as a replacement for physical travel, and on support for or rejection of several university policies (both potential and already-implemented) to reduce emissions from academic air travel. For both surveys, invitations to participate were sent out via email, with the support of actors in the respective universities' administration.

In the **FlyingLess** project, online surveys were conducted in 2022 and 2023 at four FlyingLess partner institutions (two universities and two research institutions). In addition, four (in 2022) and six (in 2023) further universities associated with the project contributed to the surveys ([Table 1](#)). In total, in 2022, eight and in 2023, ten academic institutions participated in the surveys. FlyingLess provided general information about the surveys and the link to the participating institutions, who distributed the online questionnaire internally via email. The surveys included researchers who were professors and/or group leaders, as well as researchers who were not (including doctoral students). The response rate for researchers who were professors and group leaders was around 17 % (2022) and 19 % (2023), and the rate for those who were not was 7 % (2022) and 4 % (2023). The surveys focussed on travel behaviour and attitudes towards academic air travel, including travel decisions and willingness to reduce individual business air travel, as well as consent for different flight-reduction measures.

Of course, this study comes with some limitations. It is not a single cross-case survey across three projects; therefore, the database is not consistent in terms of year/time of the surveys, academic positions of respondents included, variables measured, operationalisation and response scales. However, the pooling of results from eight surveys of researchers at all career stages – from doctoral students to professors, in different scientific disciplines, from four different years and various academic institutions in three countries – allows for data richness and a comprehensive analysis that has not been done before. Nevertheless, results may be context specific to the three projects – e.g., central European, wealthy countries with good connections to the extensive train system and few travel barriers in terms of visa restrictions and available funding. Thus, the results may differ in other contexts, such as remote academic regions or institutions

¹ <https://ethz.ch/en/the-eth-zurich/sustainability/net-zero/air-travel.html>.

² <https://transflight.uni-graz.at/en/>.

³ <https://flyingless.de/en/>.

Table 1

Overview of the surveys conducted in the ETH, Transflight, and FlyingLess air travel projects.

	Survey name ¹	Year	Institutions	Number of respondents ²	Academic positions of respondents	Documentation	
ETH	2020 professors	2020	ETH Zurich	176	Professors	Kreil, 2020b	
	2020 non-professorial staff	2020	ETH Zurich	269 95 65 34 10	Doctoral students Postdocs Senior assistants Senior scientists Other / not disclosed	Kreil, 2020b	
	2021 professors	2021	ETH Zurich	140	Professors	Wenger, 2021	
	2022 non-professorial staff	2022	ETH Zurich	343 133 61 49 14	Doctoral students Postdocs Senior assistants Senior scientists Other / not disclosed	Wenger, 2022	
Transflight	2020 all academic staff	2020	University of Graz	99 93 78 3	Professors Other academic staff with doctoral degree Academic staff without doctoral degree Other / not disclosed	Schreuer et al., 2023 ; Thaller et al., 2021	
	2022 all academic staff	2022	Three Austrian Universities ³	242 278 233 5	Professors Other academic staff with doctoral degree Academic staff without doctoral degree Other / not disclosed		
	FlyingLess	2022 all academic staff	2022	European Molecular Biology Laboratory (EMBL) Max Planck Institute for Astronomy (MPIA) University of Konstanz University of Potsdam University of Hildesheim University of Mannheim Osnabrück University Technical University of Applied Sciences Wildau	218 439	Professors and group leaders Researchers without professorship or group lead (incl. doctoral students)	Görlinger et al., 2023 ; Merrem and Görlinger, 2023a
		2023 all academic staff	2023	European Molecular Biology Laboratory (EMBL) Max Planck Institute for Astronomy (MPIA) University of Konstanz University of Potsdam University of Mannheim Osnabrück University Technical University of Applied Sciences Wildau Universität Hamburg Oldenburg University TU Dresden University of Technology	582 1223	Professors and group leaders Researchers without professorship or group lead (incl. doctoral students)	Merrem and Görlinger, 2023b

¹ These survey names refer to the name we have given to each survey in this article ([Supplementary Tables A1-A11](#)).² The number of respondents provided in [Table 1](#) can deviate from the sample sizes stated in the documentations, as we restrict the sample to academic staff, although some of the surveys also included students and/or administrative staff.³ Due to data protection agreements with the universities participating in the survey, the names of the universities cannot be listed here.

with fewer funding opportunities.

4. Results and discussion

4.1. Researchers' perceptions of air travel and reducing it (RQ 1)

To address RQ1, this section examines to what extent researchers see the need for air travel reductions and are personally willing to reduce. Furthermore, we explore perceived consequences of air travel reductions and finally turn to perceived expectations on professional travel in researchers' immediate environments.

Our data shows that researchers see the need for academic air travel reduction and are also willing to reduce their own flights (Supplementary Table A1). Respondents from all three projects were willing to reduce their air travel, either by choosing another transportation mode or participating virtually as an alternative to air travel (Fig. 1B, Supplementary Table A1). However, Transflight 2020 respondents were unwilling to reduce their air travel by abstaining from events altogether. As open-ended comments from Transflight and FlyingLess respondents indicated, this willingness to reduce air travel instead depended on alternatives' perceived availability and adequacy (e.g., available rail connections and rail travel comfort, and virtual formats' adequacy for various meeting purposes). Generally, it was highest for mode shift and lowest for abstaining from events altogether. This willingness to reduce also was reflected in how all three projects' respondents perceived air travel reduction as important (Fig. 1A). ETH and FlyingLess respondents elaborated in open comments that the university should reduce its air travel emissions to lead as a role model, remain in line with its values and mission, and ensure its researchers' credibility.

Previous studies reported similar findings on researchers' concerns about their air travel emissions and their willingness to curb their professional travel to reduce GHG emissions (Haage, 2020; Nursey-Bray et al., 2019; Schrems and Upham, 2020; Tseng et al., 2022c; Whitmarsh et al., 2020). However, it cannot be assumed that this general willingness immediately or automatically translates into actual air travel reductions. Researchers still feel compelled to fly and employ various justification and rationalisation strategies to cope with this dissonance (Schrems and Upham, 2020).

To explore why researchers struggle to reduce their air travel, even when they are willing to do so, we now take a closer look at academic practices and at cognitive norms. Researchers were worried about reducing their air travel due to its perceived relevance in their academic careers (Supplementary Table A2). ETH respondents worried about reducing their chances of a successful future career, as well as about several other consequences if they reduced air travel. Most importantly, respondents worried about missing opportunities to build personal relationships with people working elsewhere (Fig. 1E).

These results match those obtained in extant research. Storme et al. (2013) found that many researchers stated that those who travel have an advantage over those who do not, particularly in terms of international recognition. Other studies have found that many researchers are worried that flying less would limit their career progression and that a 'fear of not flying' does, indeed, exist (Le Quéré et al., 2015; Nursey-Bray et al., 2019). In other words, many established practices in academia, which serve key purposes (forming and maintaining networks, initiating collaborations, getting feedback on one's work, etc.) and ultimately the goal of advancing one's academic career, rely on extensive air travel and thus make individual researchers reluctant to reduce their air travel.

Furthermore, while established practices around career progression partly shape researchers' concerns over air travel reductions, we assume that they are also shaped by cognitive norms within academic communities (Supplementary Table A3). Interestingly, Transflight 2022 respondents did not believe that those in their immediate professional environments (colleagues, superiors) expected them to travel by air for work, although they felt that their universities expected them to be internationally mobile (Fig. 1C and 1D). Open comments from Transflight and FlyingLess did not point to specific expectations that individual colleagues or superiors should engage in air travel, but rather to more abstract assumptions that academic communities expect individual researchers to be internationally mobile.

In line with our findings, a previous study from a German university found that university and project expectations were reasons why researchers needed to fly (Schrems and Upham, 2020). Institutional expectations to fly are linked to universities' internationalisation strategies (Glover et al., 2017), and the norm that mobility is viewed as an integral part of a university's business (Hopkins et al., 2016). Thus, 'academic air travel appears to be a product of socially held expectations around mobility, exposure and connection – and the essential nature of these qualities for the academic career' (Glover et al., 2019, p. 460). Thus, continuously reproduced and shared expectations of academic air travel's centrality may exert stronger pressure on researchers than immediate peers' concrete expectations.

At a more general level, the researchers in our study generally perceived air travel to be an integral part of working in academia (Supplementary Table A4). In open-ended comments, several ETH, Transflight and FlyingLess respondents emphasised that for them, air travel is a necessity for scientific productivity, international collaboration, career development and personal motivation. This also translated into air travel becoming part of researchers' professional identities.

The literature indicates that the perceived necessity of air travel among researchers and its role in their professional identities can be interpreted as an effect from air travel being understood as directly linked to success and academic excellence (Eriksson et al., 2020; Hopkins et al., 2019; Nursey-Bray et al., 2019; Schrems and Upham, 2020; Storme et al., 2017). However, recent studies have questioned the link between air travel and academic excellence, finding little correlation between researchers' air travel emissions and their academic success, as measured by the h-index (Wynes et al., 2019), academic social capital (Schaer et al., 2021) or number of citations (Chalvatzis and Ormosi, 2021). Berné et al. (2022) found a correlation between flights and h-index, but raised the question of whether travel helps researchers increase their visibility or whether scientists who are particularly visible travel more often due to their reputation. These results thus also call into question to what extent individual researchers do in fact depend on the practice of extensive

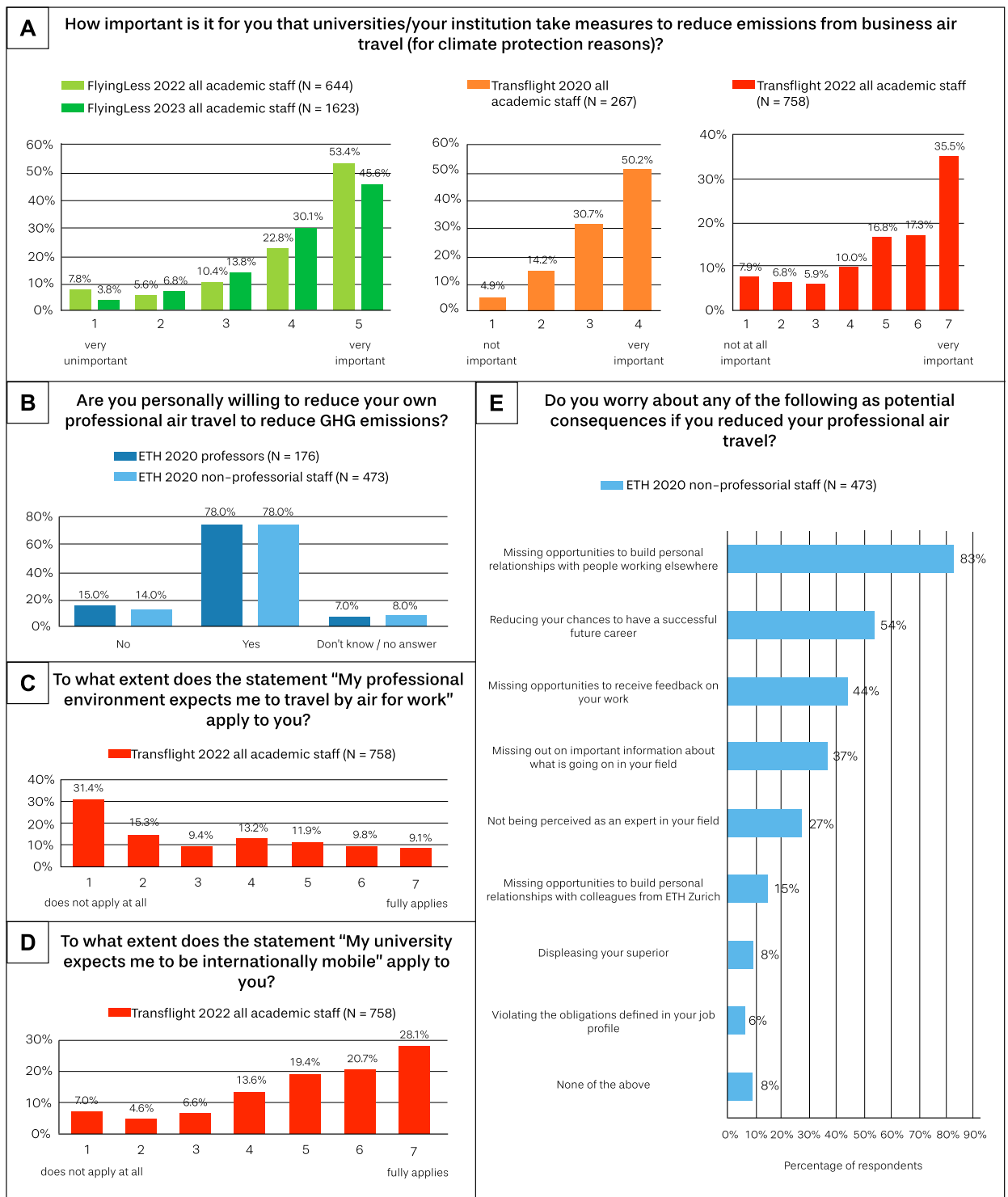


Fig. 1. Survey results on researchers' perception of air travel reduction. Further details can be found in the Supplementary Tables A1-A3.

travel to achieve the goal of building a successful career, and that consequences of air travel reductions may be less severe than expected.

To sum up, this section has demonstrated that researchers see the need for air travel reductions and individual researchers are in principle willing to reduce their air travel. These perceptions and dispositions are, however, attenuated by established academic

practices that are premised on extensive air travel and make reductions difficult for individuals. Furthermore, cognitive norms, such as collective understandings of academic air travel as important and as an integral part of working in academia, further shape researchers' perceptions and inhibit substantial reductions.

4.2. Significance of conferences for researchers (RQ II)

To address RQ2, this section now turns specifically to conference air travel and to researchers' perceptions on the significance of conferences. More specifically, we present data confirming that conferences are among researchers' main reasons for travelling and explore which aspects of conferences matter most to respondents.

As previous research has already indicated (Lassen, 2006; Storme et al., 2013; Wynes and Donner, 2018), conference attendance is a central reason for academic air travel (Supplementary Table A5). Our surveys found that Transflight and FlyingLess respondents rated conferences (particularly conference presentations) as important reasons for their air travel. More specifically, Transflight and FlyingLess respondents perceived the practice of conference attendance as important in building and developing their academic reputations and careers (Fig. 2A). Thus, the concerns discussed in the previous section on air travel reductions' detrimental effects on career development are particularly pronounced for the practice of conference air travel.

Indeed, results from Transflight indicated that academic exchange and maintaining/building networks (see Section 4.1 on the importance of networking for air travel) are two very important aspects of conferences and workshops (Fig. 2B, Supplementary Table A6). As one Transflight 2022 respondent noted in an open comment: 'Attending an academic conference is mostly about informal encounters, having lunch with people you knew or last-minute coffees with people who you met there. It [...] also has to do with meeting colleagues who work in the same field but with different approaches or themes, and you could not meet them otherwise, but you reconnect and learn informally about each other's work'.

Previous literature confirmed that conferences are an integral part of a researcher's academic career (Edelheim et al., 2018; Rowe, 2018; see Section 2.2). Hopkins et al. (2016) argued that conference air travel is perceived as necessary for researchers' careers because 'international partnerships/collaboration and presentation of research findings at international conferences [are] key indicators of academic performance, and part of the recruitment and promotion processes' (p. 392). Interviewees from another study on German researchers stated that air travel and the networking opportunities it provides were necessary for their academic careers, particularly for early-stage researchers (Schrems and Upham, 2020).

In terms of our theoretical framework, the practice of conference air travel serves the key purpose (among others) of building and maintaining networks, which ultimately helps to fulfil the goal of successfully pursuing an academic career. However, it is important to

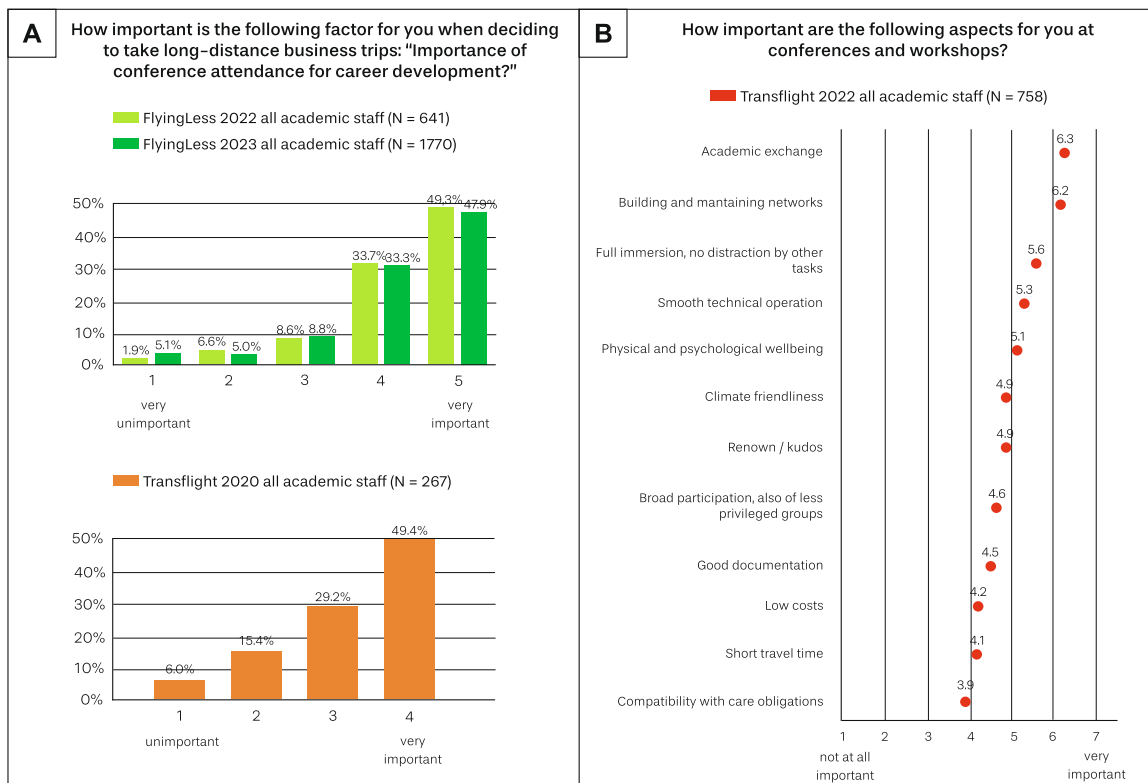


Fig. 2. Survey results on the perceived significance of conferences for researchers. Further details can be found in the Supplementary Tables A5-A6.

keep in mind that the same purposes and goals could also be served by different practices. The following section therefore examines researchers' perceptions of alternative practices to fulfil these purposes and goals.

4.3. Researchers' perceptions of alternatives to conference air travel (RQ III)

To address RQ3, this section first examines which factors influence individual travel decisions of researchers in terms of mode choice and in terms of deciding for or against the use of virtual communication instead of a business trip. In a second step, we take a closer look at virtual formats and explore how the perceived suitability of such formats has changed during the COVID-19 pandemic, which preferences for in-person, hybrid and fully virtual conferences remain, and which aspects of fully virtual conferences are perceived as effective/satisfactory or ineffective/unsatisfactory.

One strategy for reducing academic air travel comprises shifting from travelling by plane to ground-based transportation modes, such as trains and buses (Supplementary Table A7). Transflight and FlyingLess respondents indicated that various factors influence their travel practices in terms of transportation mode choice, such as travel duration and comfort, the possibility of working while travelling, environmental friendliness, the trip's costs and the transportation mode's safety and reliability (Fig. 3A). While some of these factors, particularly environmental friendliness, do not favour air travel, many others, such as costs and trip duration, tend to favour it. Furthermore, the Transflight survey found that 19% of respondents were dependent on travelling by plane due to family care obligations⁴ or other work commitments,⁵ a topic also acknowledged in open comments in the FlyingLess survey: *'Time away from family is an important factor, especially with very small children, where half a day [...] can make a big difference'*. Open comments from ETH, Transflight and FlyingLess also pointed to significant concerns regarding train journeys' duration, reliability and comfort. Comfort concerns included frequent changeovers (including the risk of missing connecting trains), inconvenient departure and arrival times, trains being overcrowded and the inconvenience of sleeping on a night train. As one Transflight 2020 respondent stated: *'I am prepared to switch to travelling by train, if it is not necessary to change trains an indefinite number of times, where the connection can be missed each time, the seat reservation for the connecting train then is no longer valid and it is packed like sardines'*.

The literature confirmed our findings, identifying similar factors for mode choice, such as travel time, costs, comfort and concerns about climate change, as well as available budgets, mobility impairments, family commitments and care obligations (Bradley et al., 2020; Haage, 2020; Hopkins et al., 2019; Storme et al., 2013). Although a comparatively longer net-travel time by train and a need for additional overnight stays prevented researchers at Leiden University from taking the train due to incompatibility with work and family obligations, they were more willing to do so when presented with a travel time comparison (train/flight) that included airport procedures (de Boer et al., 2023; van der Vliet et al., 2024). We now turn to the question which factors influence the decision for or against videoconferencing. Regardless of the particular purpose that virtual formats are used for (conferences, project meetings, etc.), the Transflight and FlyingLess results emphasise various factors' importance in respondents' decisions to rely on videoconferences instead of engaging in physical travel (Fig. 3B, Supplementary Table A8). Respondents felt that previous experiences with connection quality during videoconferences, IT support availability and access to virtual technology were important factors in deciding whether to use virtual formats. In the open-ended comments, some Transflight and FlyingLess respondents outlined which IT infrastructure and support improvements would make reliance on virtual formats more attractive. Notably, this included providing access to high-functioning platforms for virtual events, equipping each workplace with necessary hardware for videoconferencing, providing videoconferencing booths for staff working in multi-person offices and support to organise virtual, particularly hybrid, events. ETH respondents added that to increase virtual conferences' effectiveness in terms of informal exchanges and networking, technological platforms for playing online games, better chat functionalities, discussion rooms after presentations and virtual whiteboards are crucial, as are the need for conference attendees' contact details, one-on-one speed-dating opportunities and a conference space in which one can move around freely (e.g., with an avatar).

To sum up in terms of our theoretical framework, both for mode choice and for deciding over the use of virtual communication instead of a business trip, elements of material culture are key. For mode choice, this concerns rail infrastructure, available connections and comfortable and safe train equipment. Additional factors such as time constraints and costs also play a role. For videoconferencing it extends to hardware, rooms, IT support and platforms for videoconferencing.

Though we have so far treated mode choice and the decision over substituting trips with videoconferencing on equal terms, it is important to note that shifting to ground-based transportation is feasible only for substituting short- and medium-haul flights. Since these trips represent only a small portion of total aviation emissions and intercontinental long-distance flights often cause more than half of a university's air travel emissions (Bagutti et al., 2024; Ben-Ari et al., 2024), the remaining part of this section, delves deeper into researchers' perceptions of substituting air travel with virtual attendance at conferences, which can be applied to all types of flights. COVID-19 boosted the practice of holding conferences in virtual or hybrid formats (Supplementary Table A9). The Transflight and FlyingLess surveys found that respondents' willingness to use virtual formats increased during COVID-19 (Fig. 4A and 4B). However, ETH and Transflight respondents' open-ended comments indicate that this increase in willingness needs to be interpreted cautiously. While some respondents explicitly welcomed the shift to virtual and hybrid formats, others adapted to these new practices only reluctantly, as they felt they had no other choice. A few respondents also indicated that their initial enthusiasm about virtual

⁴ The statement 'When travelling for work within Europe, I depend on air travel because I have caring responsibilities (e.g., children), and can thereby be back home faster' applied to 19% of Transflight 2022 respondents, but did not apply to 72%, whereas 9% expressed no clear tendency.

⁵ The statement 'When travelling for work within Europe, I depend on air travel in order to get back to my other work commitments quickly' applied to 32% of Transflight 2022 respondents, but did not apply to 57%, whereas 11% expressed no clear tendency.

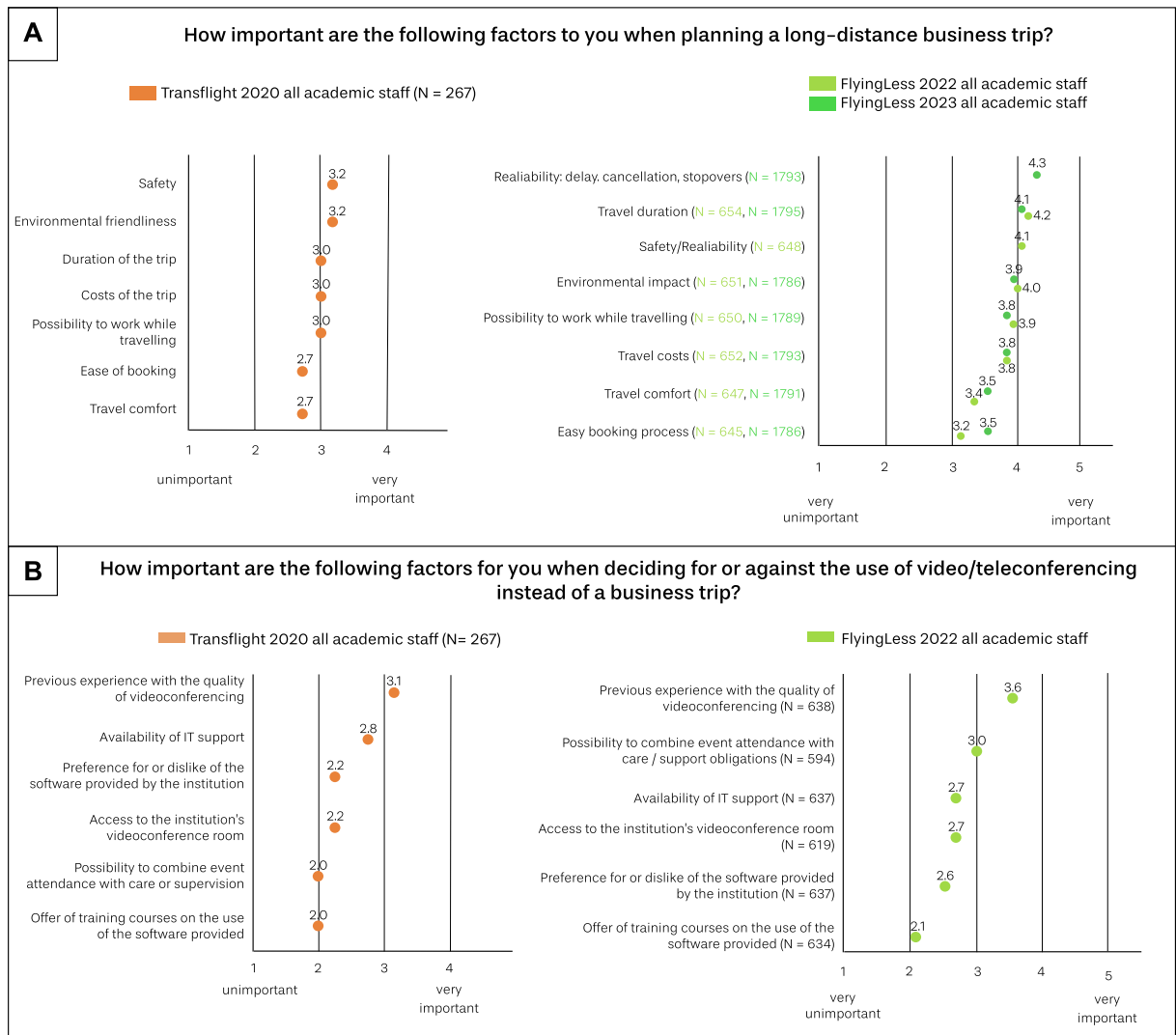


Fig. 3. Survey results on travel decision factors. Further details can be found in the Supplementary Tables A7-A8.

events soon diminished as they began to perceive several disadvantages of these formats, such as fewer discussion and networking opportunities, as well as screen fatigue.

Similarly, it has been argued in the literature that researchers gained considerable experience organising virtual conferences during COVID-19 (Porwol et al., 2022). Other studies have indicated that this shift to virtual conferences was viewed as an opportunity to reimagine entrenched conference practices and make them more sustainable (Moss et al., 2021; Niner et al., 2020). In open comments, several ETH, Transflight and FlyingLess respondents argued that virtual formats are not very suitable for conferences, as those are multiple-day events and require interactive communication among a large group of people, many of whom have not met before. In light of conference attendance being such a central reason for academic travel (see Section 4.2) and ground-based travel's limited scope as an alternative, this presents a severe challenge in seeking air travel reductions in academia.

Indeed, scepticism towards virtual formats – and, to a lesser extent, the use of hybrid ones – as a permanent replacement for in-person conferences remains high (Supplementary Table A10). The perception among ETH respondents was that a permanent shift to virtual conferences would affect their academic careers negatively (Fig. 4C). Thus, respondents preferred the in-person conference format to the virtual one. As for hybrid conferences, opinions differed, as a permanent switch to this format was perceived less negatively (Fig. 4D), with the format receiving average preference rankings similar to in-person conferences.

In line with this, previous studies have found that in-person conferences were preferred to virtual conferences (Tseng et al., 2022c; Whitmarsh et al., 2020). Similar results were found in a survey among early career researchers in environmental psychology, in which respondents sensed that a shift towards virtual conferences would impact their conference experience negatively, while switching to hybrid conferences was received more positively (Köhler et al., 2022). This preference for hybrid formats also could be because those

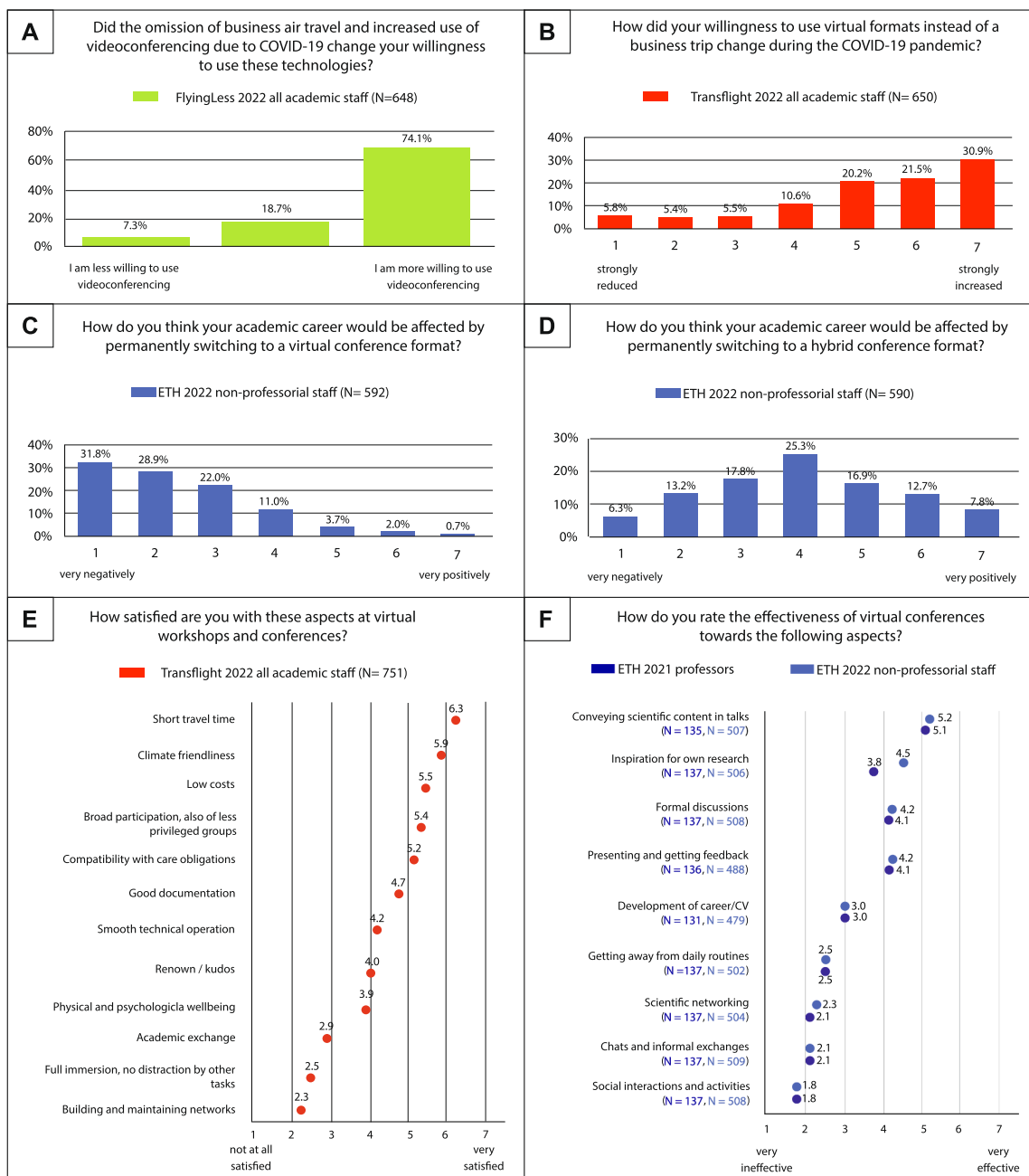


Fig. 4. Survey results on researchers' perception of virtual and hybrid conferences. Further details can be found in the Supplementary Tables A9-A11.

who have travelled to conferences in the past will continue to do so, and because virtual attendance at hybrid conferences is mainly viewed as an add-on opportunity for those who would not have been able to travel to the conference otherwise. Thus, a shift in conference practices in this direction could elicit an increase in GHG emissions without eliminating existing inequities. ETH and Transflight respondents had mixed opinions on virtual conferences, perceiving some aspects as satisfactory/effective overall, while others were perceived very negatively (Supplementary Table A11). On one hand, respondents acknowledged several benefits from virtual conferences, including climate friendliness, inclusivity/diversity, low costs, elimination of travel time, the possibility of documenting and recording, and compatibility with care obligations. For example, one FlyingLess 2023 respondent said: 'I believe that [...] the scientific community will grow a lot and become more international and inclusive if we allow virtual attendance, while at the same time offering an environmentally sustainable alternative'. On the other hand, ETH and Transflight respondents stated that virtual conferences also came with serious drawbacks, such as a lack of personal feedback, not being able to become fully immersed in the conference,

difficulties maintaining focus and time-zone differences, which also can affect compatibility with care obligations negatively. Above all, ETH and Transflight results indicate that a lack of social interaction, chats, other (in-)formal exchanges and networking were perceived as profound challenges (Fig. 4E and 4F).

The perceived exchange and networking deficits carry particular weight, as these aspects also are viewed as the most important aspects of conferences (see Section 4.2). As one ETH 2022 respondent said: *‘Without personal informal contact at conferences, it is difficult to build profound long-term relations with colleagues only via Zoom’*. As far as effective networking is concerned, open-ended comments from ETH and Transflight point to a variety of conditions viewed as relevant and found to be lacking in virtual settings, notably informal side discussions in small groups, talking over food and drinks, chance encounters and nonverbal communication. Furthermore, respondents noted that limited networking opportunities at virtual conferences affected two conference purposes particularly negatively: initiating new collaborations and enhancing early career researchers’ career prospects.

These findings concerning virtual conferences’ perceived benefits and drawbacks align with those of previous studies. It has been found that virtual conferences are more inclusive in terms of broadening participation to attendees of various genders, geographic regions and career stages, as well as attendees with visa issues, disabilities, low funding and care obligations (Huyck et al., 2021; Le et al., 2020; Owusu-Gyamfi, 2024; Skiles et al., 2021). However, challenges with virtual conferences – such as time-zone differences, issues with technical functionalities and data security – also have been identified in other studies (Foramitti et al., 2021; Moss et al., 2021; Schwarz et al., 2020; Strengers, 2015; Tseng et al., 2022c). Furthermore, conference organisers are concerned about losing financial revenue from moving to virtual or hybrid formats (Ruediger and Cooper, 2021). Virtual conferences’ biggest disadvantage was identified as a perceived lack of social interaction, chats, (in)formal exchanges and networking (Foramitti et al., 2021; Seidenberg et al., 2021; van de Glind and Gomez-Baggethun, 2022). However, interviews with virtual conference organisers and attendees indicated that networking during virtual conferences is, indeed, possible if several factors – such as conference organisers’ creative thinking and efforts, technical resources, group composition and specific sessions for discussions – are considered when planning virtual conferences (Wenger, 2023). In other words, virtual conferences still lack established practices that serve the key purpose of building and maintaining networks, but developing and establishing such practices in the future could indeed be possible.

5. Conclusion

A reduction in air travel is crucial to reach global climate goals, as technological advancements alone are insufficient to mitigate aviation’s climate impact (Sacchi et al., 2023). In this article, we drew on data collected through several surveys conducted separately as part of three air travel projects in Switzerland, Austria and Germany.

The surveys revealed that although air travel is embedded in researchers’ professional identities through cognitive norms, researchers recognise the need to reduce academic air travel. Regarding cognitive norms’ role in shaping researchers’ conference air travel behaviour, our results indicated that superiors and colleagues’ expectations, and institutional expectations to be internationally

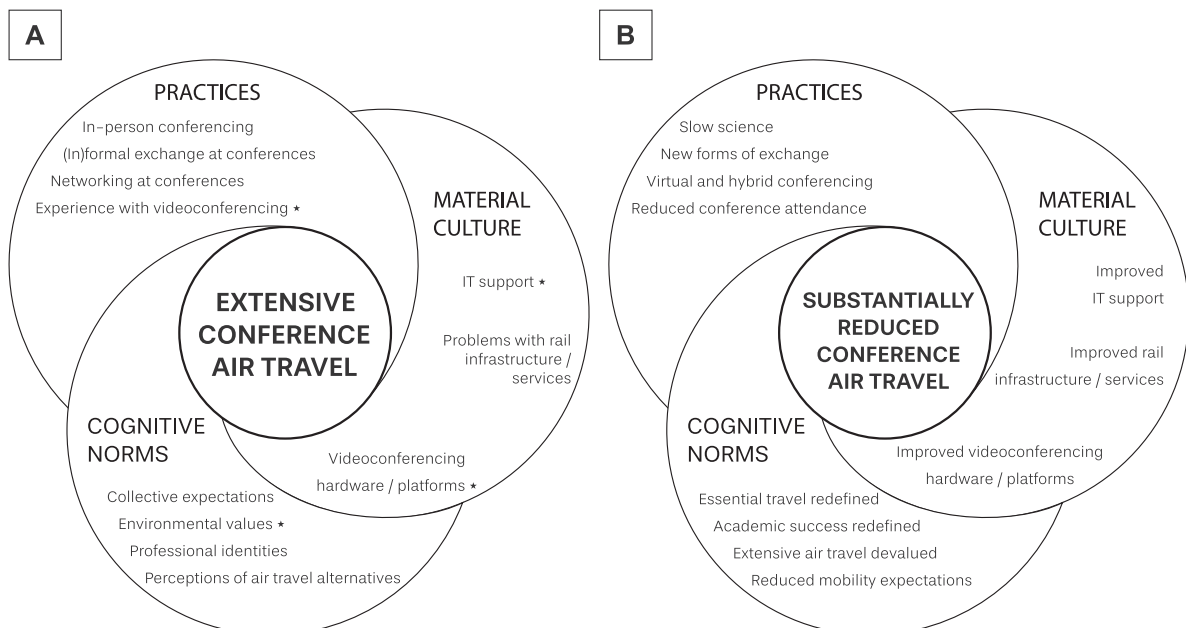


Fig. 5. Key aspects of our results and resulting recommendations concerning the reduction of academic conference air travel, embedded in the transport cultures framework.

Part A depicts the status quo and part B our recommendations. In part A, factors marked with * constitute potential seeds for change, i.e. they (partly) work against extensive academic conference air travel.

connected even more so, influence researchers' decisions to travel. Thus, researchers increasingly might be facing conflicting cognitive norms, with both international cooperation and environmental stewardship high on their agendas.

Furthermore, the surveys indicated that conference attendance practices are strong pull factors for researchers to travel by air, as they fulfil important career purposes, such as maintaining and building networks. COVID-19 provided an involuntary opportunity for researchers to transform these practices radically by switching to virtual conferences which have been shown to cut a conference's carbon footprint by more than 90 % (Tao et al., 2021). We found that researchers are more willing than before COVID-19 to use virtual formats and that researchers felt that virtual conferences pose both advantages and disadvantages. However, they generally were sceptical about whether this format could replace in-person conference attendance permanently, questioning virtual conferences' effectiveness in particular concerning informal interactions and networking.

Finally, our results indicated that material culture influences researchers' conference air travel behaviour, as decisions about whether to take ground-based or air transportation are dependent on transportation infrastructure and related services and aspects, such as price, comfort and compatibility with care obligations. Indeed, voices have been raised from geographically isolated countries (i.e., those far from major conference centres) and countries lacking fast train connections that air travel is necessary to attend conferences (Glover et al., 2019; Higham et al., 2019; Hopkins et al., 2019). Regarding information and communication technology, our results confirmed earlier research (Alajmi and Said Ali, 2022; Wenger, 2023) by demonstrating that researchers' decisions on whether to fly to a conference or attend virtually depend not only on technology availability and functionality, but also on the IT support provided and researchers' previous experiences with virtual conferences.

5.1. Practical implications and recommendations

Using the transport cultures framework as a conceptual lens, opportunities for behavioural change in conference air travel can be identified (Tseng et al., 2022a). The framework makes it apparent that action is needed in all three elements, as cognitive norms, practices and material culture are interlinked closely (Fig. 5). COVID-19 led to unexpected and rapid changes in practices (e.g., a shift from in-person to virtual conferences), eliciting changes in material culture (e.g., new virtual conference technology). However, these changes in practices seem to have been short-lived, as there appears to be a trend back toward primarily in-person conference attendance, although several conferences offer livestreams or other forms of additional virtual participation (Falk and Hagsten, 2023; Olechnicka et al., 2024; Ruediger and Cooper, 2021).

Our results highlight that the practice of conference air travel serves various purposes, such as academic exchange as well as building and maintaining networks (Fig. 2B), but that these purposes are not yet adequately fulfilled by virtual conferences (Fig. 4E and 4F). Thus, for a long-term transformation in academic practices that allows for significant reductions in air travel, scientific communities need to reconsider how conference purposes and long-term goals can be achieved in more sustainable ways (Köhler et al., 2022).

This will require redefining and re-evaluating what constitutes essential/worthwhile conference travel, while devaluing extensive academic air travel (de Vos et al., 2024). Embracing the principles of 'slow science', 'less is more' and 'quality rather than quantity', researchers can assess prospective benefits from conference attendance thoroughly and weigh them against associated costs (e.g., financial implications, time commitment, environmental impact) (Glover et al., 2017; Hartman and Darab, 2012). Individual researchers who adopt this approach can pave the way for establishing novel practices that also can contribute to a shift in cognitive norms. Additionally, academic institutions need to pave the way towards decreasing academic expectations on the need for travel, as a study in Finland showed that this policy is currently lacking in institutional guidelines although individual researchers support it (Ahonen and Rask, 2024).

As researchers see the need for air travel reductions and are willing to contribute to this goal (Fig. 1A and 1B), but maintain serious reservations towards virtual conferences (Fig. 4C, 4E and 4F), conference organisers need to design, test and systematically evaluate creative and innovative approaches to achieve conference purposes and goals without air travel. For example, distributing presentations and virtual interactions over a longer period of time, but for just a few hours a day, should be considered to avoid screen fatigue. New forms of academic exchange and networking also can go above and beyond the traditional conference format (Ruediger and Cooper, 2021). Researchers can organise virtual 'unconferences' that allow for asynchronous informal exchanges, brainstorming and networking (Holman et al., 2021); use social media platforms and chat forums (Sanganyado, 2020) or have regular virtual meetings to catch up on and exchange ideas in small communities (Kreil and Ullström, 2022). Scepticism towards virtual and hybrid conferences might dwindle if formats are tailored to these settings' potential, rather than just copy-pasting traditional in-person conference structures to virtual and/or hybrid domains.

Virtual and hybrid conferences can have several benefits, such as increased inclusivity and accessibility, and a democratisation of knowledge through the long-term provision of papers and presentations (Le Quéré et al., 2015; Skiles et al., 2021). However, implementing new formats also comes with challenges for the organizers. Kremser et al. (2024) organized the first multi-hub climate science conference without having any roadmap available. Significant efforts had to be made in terms of logistics and technical setup, but this also provided a chance to gain new skills and share lessons learnt with the community (Kremser et al., 2024).

As various aspects of videoconferencing technology influence decisions over substituting a trip with virtual attendance (Fig. 3B), improving experiences through virtual and hybrid formats for academic exchange and networking also will require paying attention to their material culture. First steps have been made in the availability of brainstorming platforms such as Miro, Etherpad, or Markdown (Bajpai et al., 2022). However, as yet, virtual communication does not allow for the full richness of side conversations and non-verbal communication of face-to-face interactions (Strengers, 2015; Wenger, 2023). To overcome this challenge, Maloney et al. (2020) showed that virtual reality can be one option of stimulating nonverbal communication similarly to in-person interactions and

suggested design improvements that can be implemented in the future. Further improvements are needed in platforms and tools' functionality, reliability and trustworthiness to improve virtual interaction.

These changes in material culture should be evaluated and adjusted continuously based on conference attendees' needs and perceptions (Wenger, 2023). Thus, researchers can have positive experiences attending virtual and hybrid events (practices), which can increase researchers' willingness to rely on them, facilitating a shift in cognitive norms. To encourage reliance on such formats further, universities need to provide the appropriate infrastructure (videoconferencing software, hardware and rooms) and IT support, such as for organising hybrid events. First steps have been made in this direction within the academic community by sharing guidelines and tips for organizing virtual and hybrid conferences (Bajpai et al., 2022; Bonifati et al., 2020; Ellis et al., 2022). Finally, beyond the academic sphere, changes in material culture to reduce conference air travel also require improvements in public transport infrastructures to encourage a shift toward ground-based transportation. To achieve this, partnerships beyond the academic sectors are needed (Katz-Rosene and Pasek, 2023).

Fundamental changes in academic conferences' practices and material culture can support a shift in cognitive norms in academia. Saatçi et al. (2019) show in their study that experiences with hybrid meetings are influenced not only by the technical infrastructure, but also by social and cultural dynamics, such as language, digital literacy, and cultural behaviours. Researchers need to adapt to new practices that include reduced flying over time to reach GHG emissions reduction targets defined by academic institutions and national legislation. Making such practices habitual ultimately will require a redefinition of academic success indicators (Gundling et al., 2023; Schrems and Upham, 2020). These deep-seated changes in norms and practices will be possible only if systemic lock-ins are reduced through policy-induced change implemented by different actors, including research institutions, conference organisers and funding agencies (Görlinger et al., 2023). Establishing policies, guidelines and interventions is essential to dismantle institutional barriers and adjust institutional framework conditions to favour reductions in conference air travel.

These policies can include measures that incentivise researchers to reduce their conference air travel, such as by covering the costs of first-class train tickets or sleeping coaches. However, experience from the three air travel projects has indicated that voluntary approaches are not enough to transform to sustainable conferencing. If the goal is to reduce academic air travel effectively, researchers also will need to be pushed towards embracing new practices and norms through mandatory measures, such as disallowing reimbursement of short-haul flights or assigning (gradually decreasing) carbon travel budgets to departments or schools. Implementation of such policies across academia can incentivise innovation in networking and exchange practices, underscoring the feasibility of achieving excellence in research while minimising conference air travel.

5.2. Future research

Although our surveys included a wide range of researchers, we did not analyse other stakeholders' opinions. Future studies also should be conducted with conference organisers and other stakeholders to examine their perspectives and opinions on reducing conference air travel. Future research also could evaluate the outcomes of concrete strategies implemented to reduce conference air travel. As reducing air travel emissions is an important goal not only for academic institutions but also for other stakeholders in the travel sector in many countries, particularly in the Global North, our findings and conclusions should be explored beyond academia. Finally, a more focussed analysis is needed on how this current dominant discourse of switching from plane to train can be shifted towards creating innovative solutions to reduce long-distance flights.

CRedit authorship contribution statement

Ariane Wenger: Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **Anna Schreuer:** Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **Susann Görlinger:** Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **Nicole Aeschbach:** Writing – review & editing, Conceptualization. **Eva Fleiß:** Writing – review & editing, Conceptualization. **Agnes S. Kreil:** Writing – review & editing, Formal analysis, Conceptualization. **Caroline Merrem:** Writing – review & editing, Formal analysis, Conceptualization. **Alfred Posch:** Writing – review & editing, Conceptualization. **Michael Stauffacher:** Writing – review & editing, Conceptualization. **Annina Thaller:** Writing – review & editing, Conceptualization. Ariane Wenger, Anna Schreuer, and Susann Görlinger comprised the core team for this manuscript. All other authors are listed in alphabetical order.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to

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Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.trd.2024.104488>.

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