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How the Covid-19 pandemic has transformed the landscape of transportation research: An integrative scoping review and roadmap for future research

By

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TITLE: How the Covid-19 pandemic has transformed the landscape of transportation research: An integrative scoping review and roadmap for future research

ABSTRACT: In the wake of the COVID-19 pandemic, scholars across all domains of science and engineering mobilised their efforts to address its far-reaching societal problems. Transportation researchers were no exemption. With mobility restrictions being front and centre of the pandemic, many researchers shifted their focus to this issue, and as a result, a new cohort of transportation science was developed within a short period of time. Here, we examine more than 400 studies related to the COVID-19 pandemic published across transportation journals during 2020 and 2021. The aim is (i) to scope this newly developed segment of transportation research, (ii) outline the diversity of pandemic-related issues across various divisions of the transportation field and (iii) provide a roadmap for the continuation of this line of research. Common themes in pandemic research within the transportation field are identified and existing congruence and discrepancies across findings are discussed. The study also highlights how pandemic-related topics across different domains of transportation research can be interconnected and have implications for another, requiring a holistic integrative overview. Results show that no pre-pandemic study was particularly instrumental in the development of this section of transportation literature, and that, it can be considered a nearly independent body of transportation science. It is expected that the outcomes of this work will contribute to systematising this segment of the literature and provide insights about areas where research has been produced to near saturation, as well as areas that need most attention from transportation researchers, particularly moving forward and coming out of the pandemic.

KEY WORDS: ***Transportation science; Transportation research; COVID-19; SARS-CoV-2; Pandemic***

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Introduction

COVID-19 represents a distinctive global disruption that has dramatically altered travel behaviour throughout the world spanning all modes of transport and fields of mobility study. While history has had previous global disruptions, the technological capability of modern scientists has allowed for an unprecedented response in the scientific process throughout the world simultaneously with rapid speed. However, while researchers worldwide have been responding to this natural scientific experiment quickly, the outputs of research have been largely uncoordinated. As a result, there is an urgent need to examine and characterize the vast emerging literature on the impact of COVID-19 for transport, as will be presented in this paper.

The specific structured aims of the presented analysis of this paper are (i) to scope this newly developed segment of transportation research, (ii) outline the diversity of pandemic-related issues across various divisions of the transportation field and (iii) provide a roadmap for the continuation of this line of research.

To begin the aforementioned aims, this paper explores more than 400 studies published in transportation journals from 2020 to 2021 (utilizing Web of Science categorization as discussed in the Methodology section). First, it will be noted that the study of the change in travel behaviour is manifesting differently by location and sub-domain of transport research although there are some common themes such as declining patronage and shifting working from home attitudes (as discussed in the Discussions and Conclusions). However, many findings are specific to sub-topics and different domains have proceeded with their own pace. The specific domain categorizations that are employed in this analysis reveal the diversity of impacts of COVID-19. The categories span:

1. Air Transport
2. Maritime/Sea
3. Supply Chain/Distribution
4. Mode Choice
5. Public Transport (Operation/Ridership)
6. Shared Mobility
7. Road Safety
8. Travel Behaviour/mobility changes
9. Congestion/emissions/sustainability
10. Economic Impacts
11. Active Transport
12. Pedestrian
13. Telework/Mental Health
14. Travel Risk Perception
15. Travel Satisfaction/access/equity
16. Urban Space/Land Use
17. Disease Spreading

Each of the 17 categories (and many more sub-categories) of scientific literature is presented and discussed throughout the sections of the paper to follow. Ultimately, by providing the analysis and the framework for examining the various categories of emerging research on the role of COVID-19 regarding shifting travel behaviour, researchers can better understand not just the impact of COVID-19, but new insights into fundamental travel behaviour should also emerge into the future across domains (i.e., COVID-19 is a stimuli that allows a distinctive lens on even unaffected travel behaviour since it impacts different sub-domains differently, thereby potentially revealing novel underlying behaviours that could remain hidden without such a stimuli).

The paper concludes with a discussion of common themes across studies and a commentary on the nature and quality of the published papers. Through the presented reflection, future research on COVID-19 can be guided as well as other future universal disruptions that might impact the

interdisciplinary field of transport research when large numbers of dispersed uncoordinated researchers need to evolve rapidly into unexpected directions globally and simultaneously.

Methods

The dataset of references was obtained by listing all journals indexed by the Web of Science in the category of Transportation and sourcing all articles by each of them with a distinct link to the COVID-19 pandemic. This list of journals is also accessible in Haghani and Bliemer (2022), except, here we also considered Transportation Research Interdisciplinary Perspectives which also was a major outlet for COVID-19-related publications for transportation researchers. After isolating 2020-2021 publications of each journal in Scopus, items that have mentioned one of the following terms in their title were exported to our database: "pandemic" or "COVID-19" or "SARS-CoV-2" or "coronavirus". This database includes the text file of all relevant references as well as their full bibliometric information. In addition, the bibliometric information of all publications from each journal during 2020 and 2021 were sourced separately for further statistical analysis.

A total of 438 articles were identified. The titles and abstracts of these references were subsequently screened to identify common themes and categorise them. A total of 17 categories were identified and each paper was allocated to one category. These categories included (1) air transport (n=87 items), (2) maritime transport (n=15 items), (3) supply chain and distribution services (n=33 items), (4) mode choice (n=20 items), (5) public transport operations and ridership (38 items), (6) ridesharing, bikeshare services and taxis (shared mobility) (n=21 items), (7) road safety and traffic crashes (n=23 items), (8) travel behaviour and mobility changes (n=70 items), (9) congestion, emission and sustainability effects (n=13 items), (10) economic impacts (n=11 items), (11) active and sustainable transport (n=14 items), (12) pedestrians, foot traffic and passengers (n=8 items), (13) telework and mental health (n=16 items), (14) travel risk perception (n=8 items), (15) travel satisfaction, access and equity (n=17 items), (16) urban space use and land use (n=7 items), and (17) disease spread and inter/intra city mobility (n=10 items). A subset of 25 items could not be attributed to any of the above 17 categories and were hence listed as "others". The full list of these references can be found in the Appendix. Figure 1 provides a visualisation of this categorisation, relative size of the categories and identifies the items that belong to each category. The subsequent sections provide a scoping review of the studies within these categories, followed by summary statistics, and discussions.

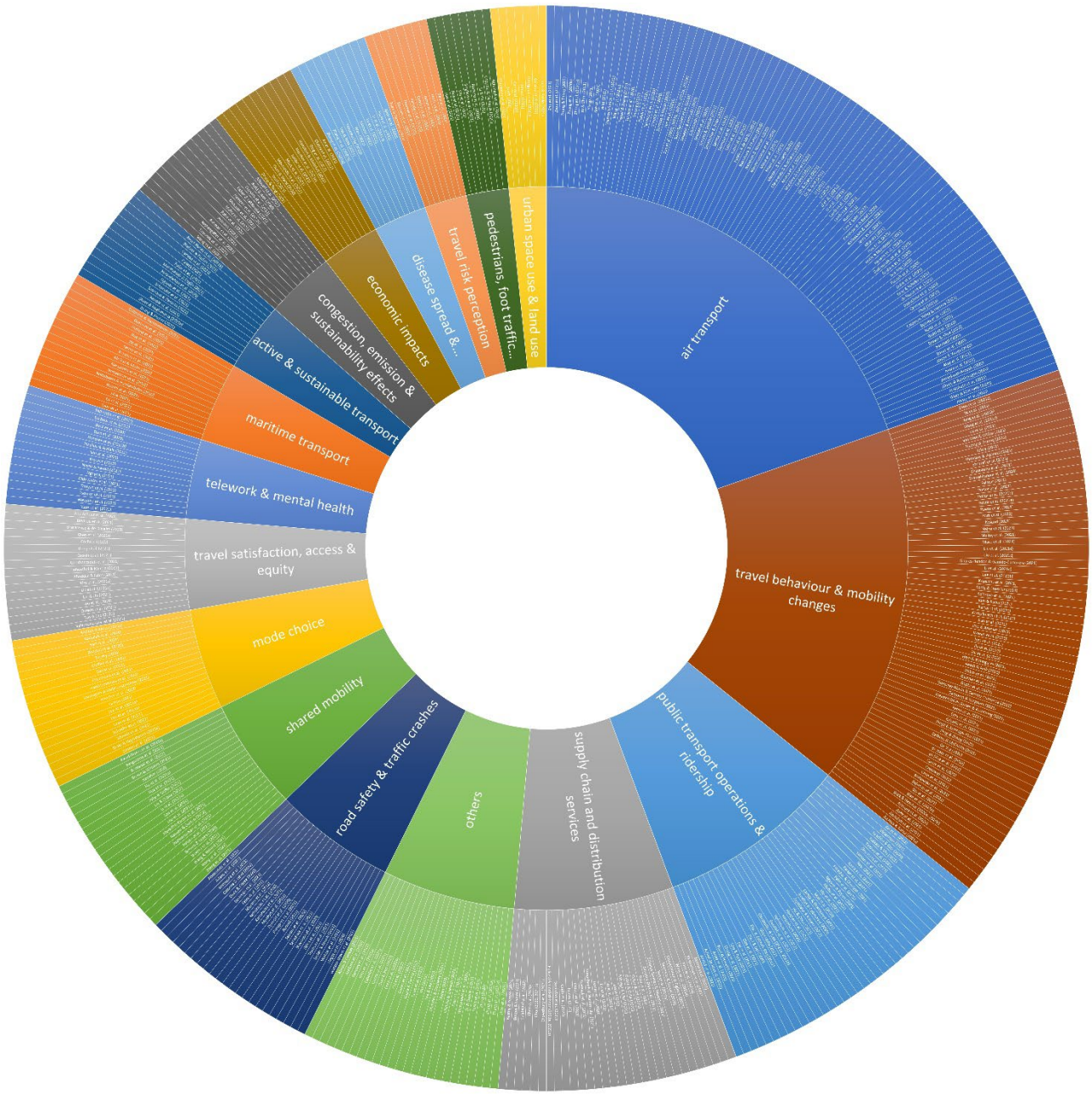

Figure 1 Pandemic related studies published by Transportation journals in 2020 and 2021, along with their common themes. A high-resolution zoomable version of the image can be downloaded from this link.

Air transport

The COVID-19 crisis and related travel restrictions (e.g., border closures) have resulted in a very significant decline of demand for air travel and a substantial shock to the supply side, too. According to IATA statistics, in April 2020 global RPKs were down 94% on April 2019 and passenger revenues fell $418 billion over the same period. Many airlines temporarily ceased all their international passenger flights, leading to the grounding of large parts of their fleets and standing down of much of their workforce; all while undertaking often challenging long haul patriation flights on behalf of their respective governments. Whilst domestic passenger operations fared better, they, too, experienced disruptions. Given the severity of the COVID-19 impact on the aviation sector, in particular international passenger services, it is not surprising that the number of COVID-19 related journal publications in the aviation domain has outperformed all other transportation modes by quite

a margin (roughly 20% of total). Whilst aviation specific reviews of the literature have covered the early stages (Tanriverdi et al., 2020) and mid stages (Sun et al., 2021f) of the pandemic, this section contributes to the literature by providing a late stage and post-COVID-19 perspective. Different to the extant literature, we further differentiate aviation into its different segments. This is important, as for example, private charter operations and air cargo have experienced not only significant demand but also yield increases. In fact, despite its volatilities, air freight operators had one of their best financial periods ever during the pandemic, which is a key differentiator to some of other modes and indeed passenger air transport. Despite this, the COVID-19 related air cargo journal literature is sparse and mainly focused on operations management due to the above-mentioned disruptions (Shaban et al., 2021) largely ignoring the success story and the newly identified role of air cargo for global supply/value chains (Merkert et al., 2017). Another characteristic of the COVID-19 air transport literature is its frequent discussion of infrastructure, namely airports (Arora et al., 2021; Choi, 2021a; Dabachine et al., 2020; de Souza et al., 2021; Forsyth et al., 2020; Hotle and Mumbower, 2021; Jarry et al., 2021; Kurt, 2021; Massaro and Rossetti, 2021; Nakamura and Managi, 2020; Serrano and Kazda, 2020; Tuchen et al., 2020; Xue et al., 2021). In the following paragraphs, we aim to discuss seven key trends and focus areas in the COVID-19 air transport literature.

(i) *The impact of COVID-19 and related government measures on the airline industry*

Unsurprisingly, the largest body of air transport literature related to COVID-19 has evaluated the impact of the pandemic on the airline industry, ranging from its negative impact on stock prices of airlines (Atems and Yimga, 2020; Maneenop and Kotcharin, 2020) to obvious poor aircraft utilization (Xue et al., 2021), turnaround times (Schultz et al., 2020; Schultz and Soolaki, 2021) and on-time performance (Yimga, 2021) as well as the broader effects on the industry (Atay et al., 2021; Dube et al., 2021; Maneenop and Kotcharin, 2020; Sobieralski, 2020) with some scholars perhaps prematurely wondering whether COVID-19 means the end of aviation as we know it (Suau-Sanchez et al., 2020). Interestingly, there is also a stream of literature that has investigated the effect of global aviation on spreading COVID-19 and the risk of importing it from inbound international flights (Nakamura and Managi, 2020; Sokadjo and Atchadé, 2020; Zhang et al., 2020a). As all this research was done prior to the advent of the Omicron variant, it's robustness today is at least questionable. With the industry imploring at the time, there were also studies evaluating the need for government support, such as subsidies or bailouts (Abate et al., 2020; Hou et al., 2021; Zhang and Zhang, 2021).

(ii) *Impact on connectivity and air networks*

Related to the first theme, this second theme focused specifically on changes to air connectivity and airline networks (Li et al., 2021c; Sun et al., 2021c), mainly from a spatiotemporal point of view (de Souza et al., 2021; Li et al., 2021b). These changes were not strategic responses of airlines but merely an operational response to government imposed (cross-border) travel restrictions and forced flight cancellations (Li et al., 2021c). What this has illustrated is that its enormous importance to global travel and value chains, aviation networks are extremely vulnerable to external shocks, such as COVID-19 (Zhou et al., 2021b). Again, one part of the aviation industry that has done relatively well, is air freight and that was notable by the advent of preighter aircraft (Merkert, 2022) and dedicated freighter aircraft not only in high demand but also by them extending their networks (Bombelli, 2020).

(iii) Strategic and operational response of airlines

Possibly the most interesting theme is that of what airlines have done in response to the pandemic (Albers and Rundshagen, 2020; Amankwah-Amoah, 2020; Arora et al., 2021; Budd et al., 2020; Kim and Sohn, 2022; Scheiwiller and Zizka, 2021; Yu and Chen, 2021). Those responses ranged from the above-mentioned grounding of fleets and standing down of staff, to situational crisis management and improved communication related to cancellation of flights (Scheiwiller and Zizka, 2021) retrenchment, persevering, innovating, and exit of routes or entire markets (Albers and Rundshagen, 2020). The innovation part is, particularly interesting as it has rather than just being a temporary response, in some cases bettered and permanently transformed the industry. For example, research has revealed more efficient and COVID-19 safe ways to board aircraft (Milne et al., 2021; Salari et al., 2021; Salari et al., 2020) and entire business models were reshaped (Bauer et al., 2020; Budd et al., 2020; Wild, 2021). The most prominent example of that was the acceleration of the implementation of ultra-long-haul flights. Designed for the premium market, those 20h+ flights have shown to come in addition to more comfort, time savings and less risk of missing connections with the advantage of bypassing large hub airports, which has the immediate health advantage of not being exposed to COVID-19 at those busy hubs (Bauer et al., 2020) and the future advantage of not having to rely on third party countries, which seems a bonus already now with geopolitical tensions on the rise.

(iv) COVID-19 and airports

Whilst a few early papers have shown that the catastrophic impact of COVID-19 on demand was not limited to airlines but very much extended to airports (Forsyth et al., 2020), as many of them turned into temporary ghost towns overnight with consequences on non-aeronautical revenues but also airport charges, the majority of COVID-19 related airport literature is focused on the airports' strategic response to the pandemic (Arora et al., 2021; Tuchen et al., 2020) and what they can do to remain operational (Choi, 2021a) and commercially relevant in a post-COVID-19 world (Serrano and Kazda, 2020). Of particular importance are the strategic design of precautionary measures for airport passengers (Dabachine et al., 2020) and check-in and security lane operations (Kierzkowski and Kisiel, 2020), although admittedly, not much of this research appears to have been implemented in practice, judging by the chaos that was observable during the Easter holidays in 2022 at airports around the globe.

(v) Travel behaviour/choice; passenger confidence and forecasting

Similar to other modes of transport, the pandemic has also had an impact on air travel behaviour with scholars revealing reduced passenger confidence, despite becoming used to COVID-19 (Budd et al., 2021). Lamb et al. (2021) show that both social and emotional factors affect passengers' willingness to fly during and post-COVID-19 eras. With changing elasticities, scholars have further shown that forecasting of aviation demand need to adapt, too, with the jurisdiction the passengers and hence culture playing a key role (Hanson et al., 2022).

(vi) Preparedness/resilience/risk management for new COVID-19 and the environment

Although not the largest of the identified themes, we think it is important to recognise the work by Brown and Kline (2020) and others who have shown that airlines were ill prepared for an exogenous shock such as the COVID-19 pandemic (Byrnes et al., 2021; Gossling, 2020; Linden, 2021; Sun et al., 2021d; Zhu et al., 2021). Policies were not in place and when the pandemic hit, airlines learned

on the go how to manage risks related to pathological (im)mobilities (Lin and Yeoh, 2021). Advancing the literature on this Linden (2021) offers various lessons on what airline managers should learn from COVID-19 for long-term planning, including to embrace uncertainty in the organization and to proactively manage as a standard factor for long-term planning. Such planning should also include the elephant in the room for aviation, that is the environment and climate change. COVID-19 and climate change as key issue for risks and resilience have been researched in concert (Gossling, 2020) and have even found support in the public for air travel restrictions to tackle both (Kallbekken and Saelen, 2021), although more recent traffic data and the bounce in air travel globally, let the validity of these findings look at least questionable.

Maritime transport

The maritime industry plays a crucial role as an enabler and facilitator of economic growth as more than 80% of global trade in terms of volume is moved by sea (Organisation, 2022). Similar to other sectors, the COVID-19 pandemic has impacted various sub-sectors of the maritime industry and triggered corresponding responses. In this category, studies mainly focus on examining (i) *impacts on cruise shipping, tourism and the national economy*, (ii) *COVID-19 risk perception and cruise intention*, (iii) *Impacts on shipping markets and shipping accidents*, (iv) *Impacts on seaports and connectivity*, and (vi) *shipping and port management in the aftermath of COVID-19*.

(i) *Impacts on cruise shipping, tourism and the national economy*

Cruise shipping is the sector of the maritime industry that has been most affected by the COVID-19 pandemic. Research shows that there is a high relationship between cruise ship movements and infection rates in countries that accept cruise ships (Ito et al., 2020). Thus, the pandemic outbreak seriously affected cruise ports and the economy of associated countries and regions which are tourism-driven, as cruise ships were banned from entering ports. For example, Florida's ports suffered an estimated economic loss of USD 22.2 billion in 2020, in which the loss of Port Miami alone was USD 55 million while that of Port Canaveral included at least 80% of its passengers and 16,000 jobs (Silva, 2021).

(ii) *COVID-19 risk perception and cruise intention*

This research theme has emerged given the strong association between infection rates and cruise shipping. In comparing the behaviour of the Australian consumers to their UK counterparts, it was found that there is a positive relationship between COVID-19 perceived risk level and social context/media portrayal of cruising, as risk perception is amplified through media coverage, and that cruise experience does not have positive effects on cruise intentions - which contradicts earlier studies (Holland et al., 2021). Meanwhile, based on a survey conducted with Chinese consumers, Yuen et al. (2021) found that perceived benefits, perceived health threats, self-efficacy and cues to action have a significant effect on customers' perceived value towards cruise services, which in turn has direct and indirect effects on customers' cruise intention through perceived trust.

(iii) *Impacts on shipping markets and shipping accidents*

Apart from declined shipping volumes (i.e. cargo and passengers), the COVID-19 pandemic was also associated with negative impacts on shipping markets. In this respect, it was found that there is an inverse relationship between COVID cases and freight rates, in that an increase of 1% in cases reported globally would decrease the Baltic Dry Index by 0.03% and the Baltic Dirty Tanker Index

by 0.046% (Michail and Melas, 2020). This was echoed in the study of Kamal et al. (2021) which analysed the daily data of the 43 listed shipping companies on the New York Stock Exchange (NYSE) and found that shipping investors reacted adversely to the announcements of the first COVID-19 identification case in China, the first outbreak case in Italy, and WHO's declaration of a global pandemic, and the U.S. travel ban announcement. Nevertheless, a reduced number of shipping accidents was recorded as a positive impact of COVID-19 in the study of Huq et al. (2021) based on daily newspaper data in Bangladesh.

(iv) *Impacts on seaports and connectivity*

This theme attracted the most studies in the maritime industry. Similar to impacts on the shipping sector, it was repeatedly found that the COVID-19 pandemic was associated with negative impacts in the port sector, i.e. reduced cargo throughput, vessel calls, and port connectivity (Guerrero et al., 2022; Narasimha et al., 2021; Tai et al., 2021), and ports playing hub or bridge functions have been more severely hit. Using the case of Shanghai Port, Tai et al. (2021) revealed that the port's production and operation were negatively affected under three different epidemic situations, although the magnitude of impacts is not the same. Meanwhile, in modelling the impact of COVID-19 on the RWI/ISL Container Throughput Index, whose database consists of 82 international ports covering more than 60% of world container handling,Koyuncu et al. (2021) revealed that the Seasonal Autoregressive Integrated Moving Average (SARIMA) is more suitable than the Exponential Smoothing State Space Model (ETS). In terms of responses to the pandemic, Narasimha et al. (2021) found that Indian ports possessed a low level of preparedness and adaptability, whereas in another study, small ports were found to be less affected when they are highly interconnected with their neighbours (high clustering coefficient) (Guerrero et al., 2022).

(v) *Shipping and port management in the aftermath of COVID-19*

Researchers have also examined strategies for disruption and resilience management in the shipping and port sectors. In this respect, flexibility through capacity management emerged as the most prominent theme. Although capacity management used by shipping lines in the 2008-2009 financial crisis and the COVID-19 pandemic had different outcomes, it is considered to be a robust resilience strategy (Notteboom et al., 2021). To this end, Russell et al. (2021) also found that there are four components of port logistics capacity; some are static while others are adjustable. For static components, flexibility relies on the expansion of capacity mechanisms, whereas adaptive mechanisms would help to improve the utilisation of the existing capacity of adjustable components. Meanwhile, looking to the future where maritime transport patterns may change as a result of localisation, near-shoring, 3-D printing, teleworking and the like (Cullinane and Haralambides, 2021), some future research areas were identified, including research on the conditions and ramifications of an increasing regional and global entanglement of ports and consequent governance solutions, and exploring new revenue/business models for port authorities, among others (Notteboom and Haralambides, 2020).

Supply chain and distribution services

The COVID-19 pandemic has influenced supply chain research by enabling researchers to re-imagine the extent to which goods and services can be distributed at a global scale. Particularly, the Last Mile Delivery (LMD) of most supply chains – the customer-facing stage – has never been disrupted to this extent in over 40 years as the field has evolved. In the studies belonging to this category, four research

themes were evident, including: (i) *changing shopping behaviour and LMD operations*, (ii) *technology adoption*, (iii) *health and critical goods logistics*, and (iv) *uncertainty, risk and resilience management*. While some of these are emerging topics, others are relatively established research areas. Given the interdisciplinary nature of research in these areas, some studies could appear in more than one theme.

(i) *Changing shopping behaviour and Last Mile Delivery (LMD) operations*

Studies in this theme investigate consumers' shopping behaviour, new LMD models, and e-commerce acceptance by consumers. For example, Wang et al. (2021d), Zannat et al. (2021), Unnikrishnan and Figliozzi (2021) and Kawasaki et al. (2022) explored the impact of COVID-19 disruptions on shopping behaviour, acceptance of e-commerce and home delivery services by customers. Another stream of research explored new forms of home deliveries, including contactless joint distribution (Chen et al., 2020) and autonomous delivery robots and vehicles (Kapser et al., 2021; Pani et al., 2020). In a related study, Ozden and Celik (2021) examined how the pandemic impacted customers' cargo service quality priorities. The study finds that being responsive to complaints and quick delivery are the two most valued attributes by customers. A new stream of research has examined the social/cultural issues related to inequality in access to online delivery services (Sanchez-Diaz et al., 2021), environmental equity implications (Figliozzi and Unnikrishnan, 2021b) and socio-demographic variables (Figliozzi and Unnikrishnan, 2021a).

(ii) *Technology adoption*

LMD and urban freight transport are amongst the least digitally revolutionised supply chain operations. Several studies explored the applications of digital technologies to address supply chain and distribution challenges caused by the pandemic. To combat the virus spread, customer acceptance of autonomous delivery vehicles, as an alternative delivery mode, was explored by Pani et al. (2020) and Kapser et al. (2021). Similarly, the use of Unmanned Aerial Vehicles (UAVs) was proposed as an efficient solution to minimise unnecessary human interactions (Kunovjanek and Wankmuller, 2021; Ozkan and Atli, 2021). Other innovative solutions include mobile service operations (Choi, 2020), mobile warehouses (Srivatsa Srinivas and Marathe, 2021) and digital twins to improve the resilience of retail supply chains (Burgos and Ivanov, 2021).

(iii) *Healthcare and critical goods logistics*

An emerging number of studies have examined the nexus between healthcare and logistics systems. For example, Lemke et al. (2020) examined the implications of COVID-19 on commercial driver health, safety and stress. Calatayud et al. (2022) studied the spatial spread of the virus within trucking networks by understanding the association between network topology and infected cases. Inspired by the constraints, limited resources and regulatory considerations of managing supply chains during the pandemic, a stream of research has focused on the development of decision support systems and optimisation tools to improve the performance of healthcare logistics networks (Govindan et al., 2020; Liu et al., 2021a; Sun et al., 2021a). The effective distribution of COVID-19 testing centres and the shipping of samples between infected patients and laboratories are the other emerging research topics within the stream of healthcare logistics (Kunovjanek and Wankmuller, 2021; Ozkan and Atli, 2021).

(iv) *Uncertainty, risk and resilience management*

Not surprisingly, 'risk' has been a primary focus of supply chain research since the start of the pandemic. One stream of studies in this domain employs exploratory approaches to further conceptualise and address risk and resilience matters within an organisation and across their extended supply chains, while others utilise mathematical modelling, simulation and optimisation approaches to address similar concerns (Ivanov, 2020). Bastug and Yercan (2021) examined how competitive priorities could create competitive advantage and improve resilience by analysing the tweets and retweets between logistics providers and their customers. Lin et al. (2021) studied the impact of supply chain diversification on firm performance, suggesting that firms with a diversified supply base associate with increased profitability during disruption and recovery periods, while firms with a diversified customer base show increased profitability only in the recovery period. Mitrega and Choi (2021) explored how small and medium sized transportation companies operate under asymmetric customer relationships, suggesting such firms could benefit from implementing selective relational approaches with their customers in the time of crisis. Several studies examined how dynamic effects of a pandemic (e.g., varying customer demand, supply and transportation capacity) can impact supply chain performance. For example, the impact of prevention policies imposed by government and industries was examined by Grida et al. (2020). The findings suggest that such interventions have the highest impact on demand, compared to supply and logistics. Other research has benefited from modelling and simulation approaches to characterise how the pandemic impacted supply chains at regional, global and industry levels, including implications for transport volume and freight capacity (Loske, 2020), regional express logistics in China (Yang et al., 2021a), food retail resilience (Burgos and Ivanov, 2021) and the poultry industry (Yazdekhasti et al., 2021).

Mode choice

Several studies investigated the impacts of the pandemic on mode choice behaviours, covering a number of main themes including: (i) *short-term modal substitution*, (ii) *intentions for longer-term modal shift*, (iii) *socio-economic factors and personal norms influencing modal shift*, and (iv) *the timeline and speed of modal shift*.

(i) *Short-term modal substitution*

During the pandemic, several factors played a major role in mode choice, including awareness of the disease, number of infections, social distancing measures, perceptions of lockdowns, and curfew policies. A common impact around the world was a significant reduction in public transport ridership, of up to 70% in some countries. By and large, car was perceived as the safest mode, while cycling and walking also attracted new users who were previous transit users (Eisenmann et al., 2021). In cities with curfews and restrictions on the use of private vehicles, individuals switched to active transport modes, particularly walking (Shaer and Haghshenas, 2021a). After lockdowns and in cities with extensive cycling infrastructure, mostly in European countries, public transport was substituted by bicycle or car (de Haas et al., 2020; De Vos, 2020; Eisenmann et al., 2021; Kanda and Kivimaa, 2020; Schaefer et al., 2021; Schmidt et al., 2021). Mode substitution was, however, different across countries with less cycling infrastructure such as Australia, United States and India, where public transport was substituted mostly by private cars (Bhaduri et al., 2020; Hadjidemetriou et al., 2020; Hensher et al., 2022a; Hu and Chen, 2021; Kanda and Kivimaa, 2020; Simons et al., 2021). Also, different mode shift behaviours were observed across different cities within a country. For example, in the Hanover region of Germany, public transport was substituted by car in the metropolis even

more than medium-sized cities. Light rail and buses were replaced by car and bicycle while train was mostly substituted by bicycle (Schaefer et al., 2021). In Australia, common findings from a three-wave cross-sectional survey in the Greater Sydney Metropolitan Area (GSMA) and Southeast Queensland (SEQ) suggest that a reduction in bus and train use (of up to 40%) led to a 7% increase in car use in both areas and a 6% increase in walking only in the GSMA (Hensher et al., 2022a). In the Greater Toronto area, it appears that pre-pandemic public transport users with access to a private car switched to private vehicle or walking, while those without a car continued to use public transport for non-mandatory trips such as shopping and recreation (Loa et al., 2021b). It can be concluded that differences in transport mode substitution could relate to different habitualised behaviours as well as mode captivity where there are no other transport alternatives. As suggested by La Paix (2021), frequent public transport users in Latin America were not willing to switch to car in a stated preference experiment even during the pandemic. The inertia turned out to be a significant parameter in mode choice even during the pandemic and transit capacity restrictions in India (Bhaduri et al., 2020). Interestingly, private car users exhibited a larger inertia during the pandemic in the abovementioned studies.

(ii) *Intentions for longer-term modal shift*

Notably, commuters' mode choice is a habitualised behaviour that is not easy to change. Intentions to change their transport mode in future also varies across different countries. In Germany, respondents reported higher intentions to use or buy a bicycle or e-bike and less intentions to use a car or public transport compared to their reported use during the pandemic. These mode shift intentions, however, were by and large similar to intentions recorded before the pandemic in 2019 (Eisenmann et al., 2021; Schmidt et al., 2021). Carless people in China, who were public transport users before the pandemic, reported an intention to buy electric two-wheelers instead of cars for commuting trips and use ride-sharing for shopping and recreational trips (Luan et al., 2021). However, a study in Australia and New Zealand reported a tendency for public transport substitution with car both pre- and post-pandemic (Thomas et al., 2021).

(iii) *Socio-economic factors and personal norms influencing modal shift*

Individual-based surveys during the pandemic and post-pandemic (i.e., time after the initial wave of the pandemic and before vaccine availability) shed light into the socio-economic factors, lifestyles, and trip purposes that can influence modal shift. Common findings among different countries suggest that people in low-income groups, males, young, or less educated are more likely to continue using public transport during the pandemic (Aaditya and Rahul, 2021b; Barbieri et al., 2021; Bhaduri et al., 2020; Das et al., 2021; Hu and Chen, 2021; Pawar et al., 2021; Simons et al., 2021). Females, married people or people exhibiting eco-conscious attitudes were more likely to switch to cycling or walking, or work from home (Bhaduri et al., 2020; Schaefer et al., 2021; Simons et al., 2021). While trip purpose is undoubtedly a key factor in mode choice, survey data from different countries showed that people placed a similar level of importance on their own safety across different modes during the pandemic, regardless of trip purpose (Abdullah et al., 2020). Previous studies also attempted to disentangle the correlation between mode shift and personal attitudes and psychological aspects related to new standards of safe and socially distant travel. In a survey undertaken in Germany, travel distance turned out to be the most important factor for higher frequencies of cycling during the pandemic compared to the same period in 2019, regardless of how strongly respondents felt about protecting the climate (Schmidt et al., 2021). In another study in India, the subjective perception of

well-being associated with lockdown did not show a significant effect on active transport mode shift, while the perception regarding the efficiency of infrastructure was found to attract people to active transport (Aaditya and Rahul, 2021b). However, it is noted that people with stronger beliefs about protecting the climate were more sensitive to changing their transport mode and switching to cycling (Schmidt et al., 2021).

(iv) *The timeline and speed of modal shift*

It is unclear how fast changes in mode choice occurred after travel restrictions and social distancing constraints were relaxed. During the pandemic, the timeline for reductions in mobility varied across different modes (Bucsky, 2020) Mobility data from Apple Maps[1] also suggests that the speed of recovery in demand varied by mode. In particular, private car use increased faster than public transport in the recovery stage. If current modal preferences, mask wearing and social distancing measures are to continue, there is the potential for scarcity of parking spaces, long-lasting congestion and underutilisation of public transport services, as suggested by scenario-based studies (Ciuffini et al., 2021).

Public transport operations and ridership

Within studies that have examined the effects of COVID-19 on public transport operations and ridership, three key themes were identified, including *(i) impacts on travel behaviour*, *(ii) changes in regional and government policies,* and *(iii) social and economic effects of COVID-19 on public transport.*

(i) Impacts on travel behaviour

In most regions, a significant decline in public transport ridership has been reported due to COVID-19. However, it is worth noting that the changes in travel behaviour during the COVID-19 pandemic have not been the same around the world. While declines of more than 90% were observed in some transit systems in the United States and China (Basu and Ferreira, 2021; Kamga and Eickemeyer, 2021; Xin et al., 2021), in Hanoi, Vietnam, bus ridership was not significantly affected by COVID-19 (Nguyen and Pojani, 2021). In Sweden, travellers were found to switch from monthly tickets to single tickets, while tickets used by tourists dropped almost to zero (Jenelius and Cebecauer, 2020). Reductions in public transport ridership were found to be associated with the duration and severity of lockdowns (Xin et al., 2021). However, even after the pandemic and easing of stay-at-home policies, ridership of some mass transit systems in the United States did not return to the pre-pandemic levels. It is also worth noting that full closure was found to significantly reduce the speed of recovery (Xin et al., 2021). In the Boston Metro, potential users remained concerned about public transport safety after COVID-19 (Basu and Ferreira, 2021). Safety concerns can increase the likelihood of intention to purchase personal vehicles and reduce the use of public transport (Basu and Ferreira, 2021; Sameni et al., 2021). Sociodemographic factors, transport-related attributes (e.g., the availability of alternative modes), perception of risk, and health-related factors have also been found to significantly affect travel behaviour and mode choice during COVID-19. Low-income transit riders have shown less reductions in distance travelled and number of trips compared to high-income transit riders (Parker et al., 2021). Through a cross-sectional survey in Vancouver and Toronto, it was investigated how neighbourhood, health-related, transport, and demographic attributes affected the avoidance of

[1] Apple. Mobility Trends Report. 2020. https://www.apple .com/covid19/mobility. Accessed July 15, 2020

public transport and deferring medical care (Palm et al., 2021). Several factors were found to be associated with deferring medical care including having a low income, having no vehicle access, having a physical disability, and being non-white. The results of an investigation in Ohio showed that areas with higher infection rates and sociodemographic factors such as higher income, children at home, married, and female were associated with the largest decrease in trips (Simons et al., 2021). In the same study, in term of the purpose of trips, worships and social visits were associated with the greatest reduction in the number of trips while work- and shopping-related trips were associated with the smallest reduction in the number of trips (Simons et al., 2021). In Chicago, regions with higher percentages of educated, high-income, and white individuals were found to be associated with greater declines in public transport ridership (Hu and Chen, 2021). Observations from the Taipei Metro system showed that reductions in metro use were more pronounced in stations connected to colleges, shopping centres, and night markets (Chang et al., 2021).

(ii) Changes in regional and government policies

One of the major policies adopted by governments during COVID-19 has been towards maintaining social distancing. In a study by Kamga and Eickemeyer (2021), measures such as separating passengers from bus drivers using plastic sheeting, increasing the length of trains through the addition of extra cars, and taped-off seats on buses were reported as effective approaches to reduce the spread of the virus on public transport. It should also be noted that in confined and closed spaces with limited ventilation, the use of preventive measures such as face masks and capacity restrictions can significantly reduce the probability of the spread of the virus (Mutlu et al., 2021; Tirachini and Cats, 2020). It is reported that mandates are more effective than awareness raising campaigns (Nguyen and Pojani, 2021). In an attempt to lure riders to public transport, fare-free policies were implemented in three Chinese cities: Xiamen, Ningbo and Hangzhou. Discrepant observations were recorded in different locations and time periods. In Xiamen, a rest day free-ride policy increased ridership by 230% over five rest days while in Ningbo, off-peak free-ride policies increased subway ridership by 24% in the first month. In Hangzhou, no significant effect on the ridership was recorded due a peak-hour free-ride policy.

(iii) Social and economic effects of COVID-19 on public transport

During the pandemic, public transport agencies faced declines in demand, which in turn, led to dramatic decrease in fare revenues and budget deficits. Other factors also resulted in more budget deficits such as vehicle cleaning, reduced vehicle capacity to maintain social distancing, and increased downtime for vehicle cleaning (Auad et al., 2021). To reduce operational costs, public transport agencies have considered several strategies such as allowing the use of public transport for essential travel only, reducing services, reducing number of lanes, closing selected stations, and cancelling certain services (Diaz et al., 2021; Gkiotsalitis and Cats, 2021b). In a review, Horcher et al. (2021) proposed employing five demand management methods, including: (a) tradeable travel permit schemes, (b) slot auctioning, (c) capacity reservation with advance booking, (d) time and space dependent pricing, and (e) inflow control with queueing. Studies have shown that the public transport services in some regions have not returned to pre-pandemic levels due to adjustments in more working from home and concerns about safety on public transport, which could increase economic challenges for public transport, even after the pandemic (Hirschhorn, 2021; Vickerman, 2021).

Ridesharing, bikeshare services and taxis (shared mobility)

The COVID-19 pandemic also altered shared mobility behaviour. In this area, relevant studies mainly focused on the effects of COVID-19 on *(i) ridesharing and public transport*, and *(ii) public bicycle services and bike sharing*.

(i) Ridesharing and public transport

An investigation in Nanjing, China, indicated that pandemic control strategies significantly decreased travel demand and commuting trips, which, in turn, decreased the risk of virus transmission (Hua et al., 2021). Although people were less likely to use shared mobility (due to fear and risk) during the COVID-19 pandemic, some actions and measures have been reported to result in increased willingness to use shared mobility. The results of an investigation in Spain indicated that measures such as the provision of covers for handlebars and an increase in vehicle disinfection increased the likelihood of using shared mobility (Awad-Nunez et al., 2021a). Personal risk perception, which could be affected by several factors (e.g., built environment setting and sociodemographic factors), was also reported as a factor that significantly affected the willingness of people to use shared mobility (Rahimi et al., 2021; Wang et al., 2022). Naveen and Gurtoo (2022) proposed the use of epidemic prevention strategies for different clusters of public transport users to provide for healthier mobility. The results of a study conducted by Zheng et al. (2021) in Shenzhen, China, showed a significant reduction in taxi demand during the lockdown, which barely recovered even after the reopening of the city. It is also worth noting that taxi demand recovery fell far behind overall vehicle travel. The occurrence of some other emergencies (e.g., natural disaster) could further complicate ridesharing during pandemic. Borowski et al. (2021) investigated the combined effects of flooding and COVID-19 on evacuation ridesharing. Several factors were found to impact the willingness to share including attributes related to access to resources (i.e., preparedness and income), risk perception related to flood evacuation and the pandemic, vulnerability (i.e., social isolation), and social identity (e.g., ethnicity).

(ii) Public bicycle services and bike sharing

While cyclists do not travel in a confined area such as a bus, they can be exposed to COVID-19 through the bike surface. Expanding communication efforts on actions and policies towards a healthy community can increase the willingness to use bikeshare services (Jobe and Griffin, 2021). Hu et al. (2021a) reported that bike share services presented a more resilient option compared to other modes (i.e., walking, driving, and public transport) during COVID-19, which has also been confirmed by other researchers. For instance, Bergantino et al. (2021) reported an increase in cycling during the pandemic. In another study conducted in New York City, Wang and Noland (2021) reported that both bikeshare use and subway ridership decreased initially; however, bikeshare use returned to its normal operation while subway ridership remained significantly below pre-pandemic levels. The results of a study conducted by Padmanabhan et al. (2021) in Chicago, Boston, and New York City, showed that although cycling trips decreased during the pandemic, the average trip duration increased. In their study, it was also found that in connected and compact cities such as New York City, the duration of the trip was less than other cities. Increased average trip duration in New York City was also reported in another study conducted by Teixeira and Lopes (2020). Significant reductions in bike share use at the initiation of lockdowns has also been reported in London (Li et al., 2021a). However, during the lockdown, an increasing trend in bike share use was observed. Another observation was about

differences in trip generation between docking stations, where trips near rail stations reduced more than those near parks and hospitals (Li et al., 2021a).

Road safety and traffic crashes

Overall, studies on the effects of COVID-19 on road safety and traffic crashes can be categorised into two main domains: *(i) impacts of lockdown or stay-at-home policies on the frequency and injury-severity of crashes*, and (ii) *before-after studies*.

Across several studies, it has been reported that COVID-19 lockdowns decreased traffic volumes and vehicle miles driven, as well as the total number of crashes, fatalities and injuries (Katrakazas et al., 2020; Rudisill, 2021; Sekadakis et al., 2021; Stavrinos et al., 2020), especially during the peak hours (Monfort et al., 2021). However, lockdowns were mainly reported to increase the proportion of severe injuries and fatalities (Adanu et al., 2021; Qureshi et al., 2020; Sekadakis et al., 2021). Saladié et al. (2020) reported that the decrease in the number of crashes was higher than the decrease in mobility. An investigation of the effects of stay-at-home policies on the frequency and severity of crashes in Ohio's Franklin County indicated that these policies led to a reduction in road traffic volumes as well as congestion during peak hours (Stiles et al., 2021). Moreover, during this period, the proportion of crashes related to speeding and intoxication increased. These changes in traffic patterns were found to be associated with less crashes during morning peaks as well as crashes with higher severity. In Queensland, Australia, decreased drink-driving was observed during COVID-19 due to suspension of roadside breath testing sites and reductions in social opportunities to drink; however, drink driving persisted among some groups including those who held restricted licenses, young drivers and male drivers (Watson-Brown et al., 2021). Overall, aggressive and risky driving behaviours, and distracted driving have been reported to increase as a result of lockdowns (Tucker and Marsh, 2021; Vanlaar et al., 2021; Vinglis et al., 2020). Self-reported risky driving behaviours during the lockdown in Canada showed a 4.2% increase in distracted driving and a 5.5% increase in drinking and driving, while in the United States it showed a 7.6% increase in drinking and driving and a 7.6% increase in speeding (Vanlaar et al., 2021). Similarly, safety indicators and driving behaviour captured using smartphone applications in the Kingdom of Saudi Arabia and Greece, indicated that speeding, mobile phone use, harsh braking, and harsh acceleration increased during the lockdown (Katrakazas et al., 2020; Katrakazas et al., 2021).

An investigation into shifts in travel modes during COVID-19 in Arlington, Virginia, indicated that midday bicycle traffic in 2020 almost doubled compared to 2019, while morning bicycle traffic decreased (Monfort et al., 2021). During the evening, fewer cyclists were observed using on-road lanes, while more cyclists were observed using off-road lanes (Monfort et al., 2021). Due to shifts in transport modes, road user behaviour, and traffic patterns, a reduction in cyclist injury crash rates have been reported (Monfort et al., 2021).

Travel behaviour and mobility changes

COVID-19 has substantially affected free movement and changed travel behaviour through teleworking, restrictions on public transport use and access to recreational destinations (Beck and Hensher, 2020b; Freudendal-Pedersen and Kesselring, 2021). Changes in mobility patterns have also impacted traffic safety, the economy and income (Gupta et al., 2021; Guzman et al., 2021; Habib et al., 2021; Iio et al., 2021). Moreover, attitudes, descriptive norms, and behaviour have changed during

the pandemic (Ding and Zhang, 2021; Irawan et al., 2021; Shamshiripour et al., 2020). The examination of such characteristics is vital as the long-term influence of travel behaviour and mobility patterns could affect the post-pandemic mobility situation (Currie et al., 2021; Kopsidas et al., 2021). The evaluation of mobility patterns during different waves of the COVID-19 pandemic could also be helpful to explore how the pandemic affects mobility patterns (Bin et al., 2021; da Silva et al., 2021; Kim and Kwan, 2021). A number of studies discuss the impact of COVID-19 on accessibility, urban mobility, and pandemic measures (Gonzalez-Marin and Garrido-Cumbrera, 2021; Linares-Rendon and Garrido-Cumbrera, 2021; Shortall et al., 2021). In this section, the following themes were identified: (i) *trip characteristics*, (ii) *socio-demographic characteristics of individuals*, (iii) *policy implications*, and (iv) *mobility changes*.

(i) *Trip characteristics*

The evaluation of different dimensions of mobility patterns during the pandemic could contribute to the assessment of mobility and its management in the post-pandemic era (Cresswell, 2021). This evaluation contains several aspects, such as individuals' responses to mobility in the pandemic, trip frequency, trip purpose, and the spatial-temporal patterns of trips (Fatmi et al., 2021; Tokey, 2021). Several studies compared work- and non-work-based travel patterns (Mayo et al., 2021; Pawar et al., 2021). For example, Aaditya and Rahul (2021a) conducted a study to evaluate how individuals decrease their travel frequency. They found that willingness to reduce essential and recreational trips is higher compared to work trips. In a similar vein, Politis et al. (2021b) advanced that the number of trips decreased during the pandemic, which was more significant for non-commuting trips. Changes in travel patterns have been reported based on inter- and out-of-city travels. For instance, Li et al. (2021e) examined inter-city travel in China during the pandemic and reported a 51% decrease. On a more detailed level, travel patterns have also fluctuated based on the location of trips during the pandemic. For example, Arimura et al. (2020) claimed the population in city centres decreased up to 90% as people stayed home and less travelled to crowded central areas. This is in line with the findings of Hara and Yamaguchi (2021) that people refuse to travel in crowded areas. Indeed, a more comprehensive analysis is needed to evaluate different characteristics of travel based on trip locations.

(ii) *Socio-demographic characteristics of individuals*

Changes in mobility patterns could also vary based on various socio-demographic characteristics, attitudes, and travel behaviour of users. Previous research has discussed age, gender, income, health status, educational level, marital status, and household size (Borkowski et al., 2021; Jiao and Azimian, 2021; Park et al., 2022; Politis et al., 2021a). The impact of travelling during the pandemic based on individuals' age, gender, and income has also been discussed in previous research (Liu et al., 2021c). For instance, de Haas et al. (2020) reported that 80% of individuals decreased their outdoor activities where such effects are greater among the elderly. On the other hand, Delbosc and McCarthy (2021) discussed the (in)direct impact of the pandemic on the travel characteristics of younger adults. They reported that the long term impact of the pandemic on young adults is more complex compared to the short-term impact, which is itself significant. Porter et al. (2021) elaborated on the travel experience of young women both as users and workers in the transport sectors. Yang et al. (2021b) claimed that the impact of the pandemic on individuals could be different from person to person as some groups, such as lower-income cohorts and individuals working in tourism and transport-related fields, are more vulnerable. Different branches of travel characteristics such as attitudes, descriptive norms, protective and habitual behaviours during the pandemic have also been discussed in previous studies (Irawan et al., 2021; Shamshiripour et al., 2020). For instance, Irawan et al. (2021) claimed that the

frequency of travel during the pandemic was positively impacted by descriptive norms. Also, remote working and e-learning, along with attitudes towards COVID-19, had a direct impact on the fluctuation of activity-travel behaviour. Moreover, Ding and Zhang (2021) reported the results of a survey in Japan and claimed that avoidance behaviours are the most common type of behaviour modification.

(iii) *Policy implications*

Different policies such as the declaration of emergency, lock downs, social distancing, face mask requirements, and restrictions on the use of public transport have been applied in different regions across the world (Bian et al., 2021b; Chan et al., 2021; Najmi et al., 2021). As transport is an inevitable part of everyday life, there is a dire need for tailoring, developing, and implementing policies to protect people from COVID-19. For example, Bohman et al. (2021) discussed the changes in mobility during the pandemic in Sweden and highlighted differences in pandemic impacts based on diverse individual groups (e.g. gender, geography and mobility). They claimed that in order to offset negative consequences, transport policies must be modified to account for these heterogeneities. Some policies during the pandemic, such as teleworking and restrictions on the use of public transport, might have a lasting impact on the individuals' lifestyles. Therefore, policy adaptation and management are needed to tackle the long-term impact of the pandemic (Liu et al., 2021d). Different policy scenarios such as infrastructure extensions, mobility restrictions and values, and consequences of policies on the healthcare system have been extensively discussed in previous studies (Kartal et al., 2021; Salazar, 2021; Truong and Truong, 2021; van Wee and Witlox, 2021). The reduction in mobility requires a timely adaptation and implementation of policies from stakeholders (Gargoum and Gargoum, 2021). For example, restriction in the ridership of some transport modes (e.g. public transport) requires consolidating planning and policies to shift travel demand to other transport modes (Park et al., 2022). The decrease in the level of mobility has been considered a constructive policy in reducing virus transmission, which has been applied in different regions. Therefore, it is vital that policymakers and stakeholders take precautions in the recommendation to reopen society (Noland, 2021). Hence, there is a need to evaluate the impact of policies on the long-term lock down impacts, reopening policies, and travel demand management (Hu et al., 2021b).

(iv) *Mobility changes*

As discussed, the transport sector has been drastically affected by different policies to control the spread of the virus (Beck and Hensher, 2020a). Restrictions on the use of public transport, teleworking, and closure of recreational destinations are considered to have changed mobility patterns and habits substantially. Therefore, there is a need to evaluate changes in travel demand, mobility choices, and their long-term impact on the transport system (Hanson et al., 2022; Lee et al., 2021b; Vo et al., 2021; Ye et al., 2021; Zhou et al., 2021c). Previous research discussed the impact of the pandemic and respective policies on modal shift, including the reduction of public transport ridership, an increase in active mobility and car dependency. An extensive body of literature discussed the drastic reduction in the ridership of public transport. For example, demand for public transport has substantially decreased (De Vos, 2020; Kolarova et al., 2021). It seems that public transport is the transport mode that has been most affected by the pandemic (Echaniz et al., 2021), given restrictions on public transport use and a decrease in travel distances (Ecke et al., 2021; Molloy et al., 2021). As public transport ridership has decreased, its travel demand has been shifted to other modes. Consequently, it is shown that car dependency has increased during the pandemic situation

(Kamplimath et al., 2021; Thombre and Agarwal, 2021; Wang et al., 2021c). The reduction in public transport use could also enhance sustainability outcomes by shifting travel demand to active mobility (Abdullah et al., 2021; Konig and Dressler, 2021). However, this transition should be carefully considered as constraints on the use of public transport also led to an increase in the usage of cars. A great body of literature has discussed the extent, reasons, and proportion of such transitions in different locations (Anke et al., 2021; Dingil and Esztergar-Kiss, 2021; Jiao et al., 2021). For example, Habib and Anik (2021) discussed the decrease in public transport ridership and reported the substantial increase in bicycle sales and decline in car sales. Also, risk of infection was reported as one of the main reasons to reduce public transport use and shift to active mobility and personal cars (Shibayama et al., 2021). Yet, more comprehensive research is needed on tailoring policies to trigger individuals to use active mobility and subsequently contribute to sustainability objectives.

Congestion, emission and sustainability effects

Within studies that have investigated congestion, emission and sustainability effects of COVID-19 from a transport perspective (Hensher et al., 2021c; Mahajan et al., 2021), three key themes emerge: (i) *changes in road traffic demand* (Fisher and LaMondia, 2021; Muley et al., 2021; Patra et al., 2021; Simunek et al., 2021), (ii) *effects on air quality and emissions* (Albayati et al., 2021; Crowley et al., 2021; Polednik, 2021; Rahman et al., 2021; Wang et al., 2021a), and (iii) *future societal trends and expectations* (Budd and Ison, 2020; Rothengatter et al., 2021).

(i) *Changes in road traffic demand*

COVID-related mobility restrictions have been associated with reductions in road traffic demand (Patra et al., 2021; Wang et al., 2021a). In the City of Doha, a reduction in road traffic of 30% was estimated by Muley et al. (2021), with traffic violations and total crashes decreasing by 73% and 37% respectively. In the Czech Republic, traffic density reduced considerably, with average traffic speeds increasing by 21%. However, traffic was found to gradually return to pre-pandemic levels, even before the state of emergency was terminated (Simunek et al., 2021). In the United States, counties with higher populations or those labelled as urban counties saw a greater reduction in Vehicle Miles Travelled (VMT), as did states that introduced mobility restrictions compared to those that did not (Fisher and LaMondia, 2021).

(ii) *Effects on air quality and emissions*

Improvements in air quality and emission reductions have been associated with COVID-19 due to reduced mobility, including an increase rate of working from home (Rahman et al., 2021; Wang et al., 2021a). In a review of the effects in different countries – including India, China, United States, Italy, Brazil and Malaysia – considerable decreases in emissions were found, particularly among larger countries (Albayati et al., 2021). In Ireland, Crowley et al. (2021) estimated a 1% decrease in transport-related emissions if all those who could work from home did so for one day a week, with this increasing to 3% if those who could work from home did so on a full-time basis. In a study of road users in Lublin, Poland, Polednik (2021) estimated that the COVID-related lockdown in Spring 2020 reduced exposure to total particles by two times and traffic-related particles by more than five times, compared to pre-pandemic conditions.

(iii) *Future societal trends and expectations*

In a think piece by Budd and Ison (2020), a new concept of 'Responsible Transport' is proposed in which individuals have greater awareness of the impacts that their travel behaviour has – not only on themselves – but also on others and the environment, and act accordingly. It differs from conventional pre-pandemic approaches to transport policy by requiring an element of individual responsibility. Additionally, Rothengatter et al. (2021) discuss the role of the transport sector during the pandemic, including negative effects on maritime, air travel and public transport, but also positive effects on the environment and climate change. They also reflect on social acceptance issues of the behavioural changes necessary in a post-pandemic world.

Economic impacts

Within studies that have examined economic impacts of COVID-19 from a transport perspective (Hamilton and Maliphol, 2021), four main themes are identifiable. Transportation researchers have investigated and quantified *(i) macroeconomic impacts of lockdown and reduced traffic* within specific regions of the world (Hamilton and Maliphol, 2021; Junior et al., 2021; Zhang and Tong, 2021), the impact on *(ii) valuation of travel time savings and reliability* as major inputs for transport project appraisal models (Cherry et al., 2021; Hensher et al., 2021a), as well as the impact on the *(iii) business model and (un)employment* within the transport industry (Mack et al., 2021; Wild, 2021). Development of optimisation models to identify *(iv) optimum travel restriction strategies* constitutes another issue that transport scholars have addressed (An et al., 2021; Oum and Wang, 2020).

(i) *Macroeconomic impacts of lockdown and reduced traffic*

An investigation of the public agglomeration and economic impacts of COVID-19 in Brazil, for example, concluded that the decline of transport services during the pandemic has been the main contributing factor to the decline in GDP growth (Junior et al., 2021). Similarly, Zhang and Tong (2021) investigated economic impacts of traffic consumption during the COVID-19 pandemic in China and suggested that China's macroeconomy was severely affected as a result of reduced traffic consumption. It was also determined that, of all the transport sectors, road transport has received the largest hit, followed by the railway and air sectors.

(ii) *Valuation of travel time savings and reliability*

A critical value that is used in cost-benefit analysis of transport projects is the users' valuation of time savings. This quantity converts time into monetary units, thereby allowing for the calculation of user benefits. Considering reduced commuting during the pandemic, a reasonable question would be the impact on user valuation of time savings, and whether and in what direction this has changed during the pandemic. Two studies have investigated this problem and the findings are not in congruence. While the travel survey conducted by Hensher et al. (2021a) in Australia suggested an increase in value of time, research conducted on behalf of the Virginia Department of Transportation before and during the pandemic documented a significant decline in estimates of willingness to pay for travel time savings and travel time reliability, across all travel types, and particularly so, for commuting (Cherry et al., 2021).

(iii) *Business model and (un)employment*

An investigation into the impacts of COVID-19 on transport-related employment in the United States determined that the transport industry experienced a greater incidence of unemployment than other

industries (Mack et al., 2021). Also, within the transport industry, the impact on unemployment was not uniform and a heterogenous impact was found. In another study, Wild (2021) investigated the impact of COVID-19 on airline business models. Their findings determined that the pandemic did not cause a demand shift within business models, while also ruling out a shift in passengers' perceptions regarding corporate social responsibility.

(iv) *Optimum travel restriction strategies*

A few studies looked into the issue of travel restriction policies from the standpoint of achieving a social optimum (Oum and Wang, 2020). An et al. (2021), for example, developed an online optimisation model to identify modal-specific travel restriction strategies with the objective of balancing the benefits of epidemic control and the negative impacts on regional economies.

Active and sustainable transport

Different conditions such as increased teleworking and restrictions on public transport use during the pandemic have substantially influenced the use of different transport modes, including active mobility. The evaluation of active mobility is crucial as this mode can contribute to users' health and well-being and alleviate societal issues such as greenhouse emissions which have been highlighted during the pandemic (Musselwhite et al., 2020; Semple et al., 2021). Thus, implementing timely policies to facilitate the use of this active transport modes for society is a must (Schneider et al., 2021). However, active mobility literature during the pandemic yields little research and, consequently, few identifiable research strands. Two major research strands could be retrieved: *(i) fluctuation of active mobility* (Buehler and Pucher, 2021; Carrese et al., 2021; Fuller et al., 2021; Shaer and Haghshenas, 2021b; Zhang and Fricker, 2021), and *(ii) extent of modal substitution* (Awad-Nunez et al., 2021b; Cusack, 2021; Kazemzadeh and Koglin, 2021; Nguyen et al., 2021; Scorrano and Danielis, 2021).

(i) *Fluctuation of active mobility*

The oscillation of active mobility during the pandemic is considered to be related to different factors such as the amount of remote working, trip purpose, trip distance, time and place of use, and socio-demographic characteristics of users (Carrese et al., 2021; Fuller et al., 2021; Shaer and Haghshenas, 2021b). It seems that the overall rate of active mobility has increased during the pandemic. More specifically, recreation, exercise and well-being trips have been reported as the main application of cycling trips (Buehler and Pucher, 2021). Furthermore, active mobility substantially increased in less densely populated regions (Zhang and Fricker, 2021) and over weekends (Buehler and Pucher, 2021). There are several reasons that the increment in cycling ridership during the pandemic keeps continuing as utilitarian trips (e.g., trips to school, university, and work) have rebounded following the easing of mobility and other restrictions. Also, users who shifted from public transport to cycling during the pandemic may continue cycling in the post-pandemic situation (Buehler and Pucher, 2021).

(ii) *Extent of modal substitution*

The role of active mobility in substituting and/or supplementing other transport modes is found to be varied. For instance, Awad-Nunez et al. (2021b) conducted a survey and reported that the majority of respondents were eager to replace their primary transport mode with a sustainable one if this decision contributed to controlling or stopping the consequences of the pandemic. On the other hand, Nguyen et al. (2021) claimed that after reopening schools, the rate of active school travel has

decreased and parents, especially mothers, prevent their children from walking and cycling when there is no barrier to using motorised vehicles (Nguyen et al., 2021). Having children introduces extra responsibility, making it challenging to choose active mobility for commuting (Cusack, 2021). The findings also differed based on the type of bicycle. For example, it was reported that bicycles could replace mainly walking; however, buses and cars to a lesser extent (Scorrano and Danielis, 2021). However, electric bicycles are considered to be more of a substitute to public transport and personal cars (Kazemzadeh and Koglin, 2021).

Pedestrians, foot traffic and passengers

While highly relevant to societal issues arising from the pandemic, research on pedestrians and passengers was found to be rather underrepresented within the Transportation journals. Transportation researchers have reported on developing (i) numerical and computational models that can *simulate pedestrian exposure and disease transmission* (Li and Yin, 2021; Romero et al., 2020; Wu et al., 2021; Xiao et al., 2021). They also conducted (ii) surveys to understand *changes in pedestrian perceptions, activity and behaviour* (Aghabayk et al., 2021; Singleton et al., 2021) and also applied artificial insentience and computer vision methods to measure *social distancing in public spaces* (Zuo et al., 2021).

(i) *Simulate pedestrian exposure and disease transmission*

Indoor spaces are considered to be hotspots for virus transmission, and as such, developing modelling capabilities that can quantify transmission risk in indoor spaces is an important input to policy making. Transport researchers have recognised this need and rightly highlighted that existing epidemiological models have limited capabilities for indoor spaces as they cannot represent the dynamics of foot traffic (Xiao et al., 2021). Therefore, researchers established the need for integrating epidemiological and pedestrian simulation models for this purpose (Li and Yin, 2021). Standard models of pedestrian motion, such as social force (Xiao et al., 2021) and cellular automata (Li and Yin, 2021) were adopted and modified for this purpose. These multi-layer models were employed to investigate the effectiveness of a range of nonpharmaceutical policy measures in a variety of indoor spaces such as supermarkets (Xiao et al., 2021), university campuses (Li and Yin, 2021; Romero et al., 2020), and airplanes (Wu et al., 2021).

(ii) *Changes in pedestrian perceptions, activity and behaviour*

The impacts of the pandemic exerted effects on all aspects of travel behaviour and mobility and the behavioural effects on passengers and pedestrians was no exception. A few studies investigated these effects, and in doing so, survey methods were instrumental. For example, Singleton et al. (2021) conducted a survey to understand the changes occurring at signalised intersections as a result of lockdown based on case studies in Utah. Their case studies examined interventions that would stop pedestrians pushing the pedestrian button at intersections. Aghabayk et al. (2021) investigated the effects of COVID-19 on rail passengers' crowding perceptions by re-administering a pre-COVID-19 survey during the pandemic and comparing passenger responses. They found impacts such as an increase in the marginal valuation of having a seat on public transport as a result of the pandemic.

(iii) *Social distancing in public spaces*

With the issue of physical distancing becoming front and centre during the pandemic, researchers recognised the potential use of artificial intelligence methods to automatically detect inter-individual

distance between pedestrians in public spaces. The aim of this research is to obtain precise information on social distancing patterns of pedestrians in urban environments using video footage. Zuo et al. (2021) for example, developed a novel deep-learning method of in-video real distance approximation that is exempt from having a reference point. Such methods can inform social distancing guidelines and alert authorities of problematic times and locations.

Telework and mental health

The substitution of commuting trips with remote working introduces several challenges and opportunities to both users and society, requiring consolidated planning (Hiselius and Arnfalk, 2021; Yabe et al., 2021). From the user's standpoint, work satisfaction, mental health, and psycho-social factors could differ substantially (Waygood et al., 2021). From the societal perspective, fluctuation in the use of transport modes and the more prolonged impact of remote working on the transport network could be consequences of teleworking (Balbontin et al., 2021). Based on the reviewed literature, the following themes were identified: *(i) teleworking impacts on well-being and mental health* (Dam et al., 2020; Kroesen, 2022; Tahlyan et al., 2022; Tsouros et al., 2021) *(ii) intention and characteristics of teleworking* (Barbour et al., 2021; Jain et al., 2021; Nayak and Pandit, 2021; Nguyen, 2021), and (iii) *impact of teleworking on the transport system* (Balbontin et al., 2021; Beck et al., 2020; Hensher et al., 2021b; Olde Kalter et al., 2021).

(i) *Teleworking impacts on well-being and mental health*

Teleworking introduces various impacts depending on several factors such as employer strategies and socio-demographic characteristics of workers (Dam et al., 2020; Tahlyan et al., 2022; Tsouros et al., 2021). For instance, subjective well-being increased only for female workers who switched to teleworking from long commuting trips (Kroesen, 2022). Moreover, compared to middle-aged people, younger and older people perceived fewer advantages and more impediments to teleworking (Tahlyan et al., 2022).

(ii) *Intention and characteristics of teleworking*

Several factors such as age, gender, income, having children, education, residential location, and information technologies can affect teleworking and its long-term potential (Barbour et al., 2021; Nguyen, 2021). Teleworking during the pandemic has triggered workers to continue remotely beyond mobility and other forms of restrictions (Barbour et al., 2021). This may be due to increased levels of worker productivity through teleworking (Nayak and Pandit, 2021). Also, teleworking in the post-pandemic situation is expected to be higher than in the pre-pandemic situation (Jain et al., 2021).

(iii) *Impact of teleworking on the transport system*

Teleworking affects users' travel patterns as some commuting trips are eliminated through working from home. The literature revealed few studies that discussed the impact of teleworking on commuting travel (Balbontin et al., 2021; Hensher et al., 2021b). For example, Olde Kalter et al. (2021) claimed that car use may decrease in the post-pandemic situation as the amount of teleworking will be increased. Consequently, teleworking is expected to improve traffic congestion in developing countries and consequently alleviate environmental issues associated with motorised vehicles (Nguyen, 2021).

Travel risk perception

An important factor that shapes mobility and travel behaviour during the pandemic is(i) *perception of risk*. Another factor is (ii) *social influence* where exposure to the behaviour of others influences one's risk perception and behaviour. Multiple quantitative and qualitative surveys were conducted during the pandemic across the world in countries such as Australia (Beck et al., 2021; Thomas et al., 2021), New Zealand (Thomas et al., 2021), Iran (Zavareh et al., 2021), Japan (Parady et al., 2020), United States (Hotle et al., 2020; Ozbilen et al., 2021), Macau (Zuev and Hannam, 2021) and Jamaica (James et al., 2021). Many of these investigations were conducted in the specific context of (iii) *public transport user risk perception*.

(i) *Perception of risk*

The perception of risk of infection while travelling during COVID-19 has been shown to have clear links to traveller demographics (Ozbilen et al., 2021) as well as the mode of travel. The level of perceived risk has been found to be more pronounced for users of shared transport modes than private modes (Ozbilen et al., 2021). In particular, one study showed that taxi drivers perceive themselves at occupational risk of COVID-19, while their risk perception score correlated with their knowledge of the disease (James et al., 2021).

(ii) *Social influence*

In the context of non-binding self-restrictions, social influence has been shown to play a critical role. The perception of the degree of self-restriction among others has been shown to be associated with reductions in travel activity (Parady et al., 2020). Surveys have also demonstrated that social trust is negatively associated with perceived risk of COVID-19 infection (i.e., the paradox of trust) (Zavareh et al., 2021).

(iii) *Public transport user risk perception*

A survey of nearly 800 respondents in Australia and New Zealand during the pandemic showed that attitudes towards travel were negatively affected, particularly towards public transport and international air travel and did not recover to pre-pandemic levels. Another survey of Australian respondents demonstrated that even as COVID-19 restrictions eased, concern about crowds and hygiene remained significantly and negatively correlated with public transport use (Beck et al., 2021).

Travel satisfaction, access and equity

Within studies that have investigated satisfaction, access and equity issues associated with COVID-19 from a transport perspective (Gaskin et al., 2021; Valenzuela-Levi et al., 2021), four key themes emerge: (i) *impacts on disadvantaged groups* (Bledsoe et al., 2021; Bracarense and de Oliveira, 2021; Cochran, 2020; Hohenthal and Minoia, 2021; Oviedo et al., 2021; Tao and Cao, 2021), (ii) *access to health care services* (Chen et al., 2021a; Ghorbanzadeh et al., 2021; Kim et al., 2021a), (iii) *travel satisfaction* (Dong et al., 2021; Khaddar and Fatmi, 2021), and (iv) *perceived accessibility* (Liu et al., 2021b; Liu and Liu, 2021). A total of 17 studies were identified in this category, yet these were focused only on North America (10 studies), South America (4 studies) and China (3 studies).

(i) *Impacts on disadvantaged groups*

The pandemic has been found to disproportionally impact disadvantaged groups. In particular, those on low incomes have been less likely to be able to follow stay-at-home orders due to 'essential' work

activities, placing them at greater exposure to health risks (Lou et al., 2020; Tao and Cao, 2021). People with disabilities have also been affected, particularly those without access to a household vehicle (Abu Ashour et al., 2021; Cochran, 2020). Other marginalised groups (e.g. ethnic) have also been impacted (Kim et al., 2021a), with concerns raised over lack of social connections (Bledsoe et al., 2021), access to education (Hohenthal and Minoia, 2021) and well-being inequalities (Oviedo et al., 2021).

(ii) *Access to health care services*

Studies undertaken in the United States have found that patients who already experience transport disadvantage are likely to need extra support to overcome additional travel barriers during the pandemic, such as changes in public transport or the ability to rely on others for rides (Chen et al., 2021a). Other research has found an uneven distribution of accessibility to healthcare facilities among the population in Florida (Ghorbanzadeh et al., 2021; Kim et al., 2021a).

(iii) *Travel satisfaction*

Where public transport had resumed operations in Chinese cities following temporary closures, perceived safety was found to have a positive effect on travel satisfaction (Dong et al., 2021). In British Columbia, Canada, daily activity engagement and socio-demographic attributes were found to significantly affect travel satisfaction (Khaddar and Fatmi, 2021).

(iv) *Perceived accessibility*

Two studies undertaken in Kunming, China, investigated perceived accessibility during the pandemic. Liu and Liu (2021) found that perceived accessibility had lagged effects on mental health, while Liu et al. (2021b) found that the ease of using smartphone-based services influenced perceptions and experiences of accessibility, although this effect faded after the lifting of mobility restrictions.

Urban space use and land use

Within studies that have investigated urban space use and land use issues associated with COVID-19 from a transport perspective (Jensen, 2021; Kim et al., 2021b), two key themes emerge: (i) *reallocation of street space* (Combs and Pardo, 2021; Scott, 2021; Shirgaokar et al., 2021), and (ii) *changing priorities and future agendas for transport planning and policy* (Corazza et al., 2021; Georgouli et al., 2021).

(i) *Reallocation of street space*

The pandemic has brought about significant efforts to reallocate street space in many cities worldwide in response to changes in mobility (Scott, 2021). Combs and Pardo (2021) describe the Shifting Streets COVID-19 Mobility Database which documents changes to the allocation of street space and other transport resources during the pandemic in over 500 cities across 60 countries. All changes were found to take less than five months, with most taking substantially less time. Drawing on the dataset described by Combs and Pardo (2021) and the use of Twitter, Shirgaokar et al. (2021) found that individuals reported a positive change in their quality of life in response to street space reallocation efforts due to the availability of outdoor space for walking, cycling, and socialising.

(ii) *Changing priorities and future agendas for transport planning and policy*
Georgouli et al. (2021) found that transport planning priorities and policy making has been significantly affected by the pandemic, particularly those relating to active transport, safety, security and resilience. A lack of emergency planning and preparedness in response to the pandemic was also found, consistent with Corazza et al. (2021) who emphasise the need to consider different fields of action beyond the urban mobility management sphere.

Disease spread and inter/intra city mobility

A cohort of studies published during the pandemic investigated the role that transport networks and mobility restrictions played in control and/or spread of the disease. This has been investigated at both an inter-city (Li et al., 2021d; Zhang et al., 2020b) and intra-city level (Manout, 2021). Within this cluster of pandemic-related studies two major themes are identifiable, one that looks at the (i) *effect of human mobility on disease spread* and one that investigates the (ii) *effectiveness of mobility restriction measures and policies on disease spread*. While case studies extend to many areas of the world including Canada (Manout, 2021), Italy (Fazio et al., 2021), Nigeria (Ajide et al., 2020) and United States (Zhang et al., 2021b), a recurring theme is the spread of cases originating from Wuhan, China (Li et al., 2021d; Zhang et al., 2020b).

(i) *Effect of human mobility on disease spread*
Case studies of this group were mostly conducted in the context of China and focused on travel out of epicentres of disease (Wan, 2021), mainly Wuhan, suggesting that the most effective way to prevent the virus from spreading quickly and extensively is to control the routes linked to the epicentre at the beginning of the pandemic (Lu et al., 2021). Zhang et al. (2020b) and Li et al. (2021d) have, for example, both provided evidence showing that frequencies of air flights and high-speed train services out of Wuhan were significantly associated with the number of cases in destination cities.

(ii) *Effectiveness of mobility restriction measures and policies on disease spread*
These studies have explored the impact of relevant characteristics of counties, states, cities and provinces and their relationship with increases in COVID-19 cases before shelter-in-place or lockdown orders (Yoo and Ross, 2021). Yilmazkuday (2020) for example, reported that the number of cases lowered with less inter-city travel within the United States and quantified the extent to which restricting inter-city travel contributed to the containment of disease. Ajide et al. (2020) similarly studied the effectiveness of lockdowns based on six major indicators. Zhang et al. (2021b) compared more than 400 policy measures (including transport measures) implemented in six different countries. In addition to the case studies conducted based on the reported number of cases and actual policies, studies have also reported on simulation testing of these policies, where agent-based models are implemented to determine the impact of mobility restrictions on disease spread. A common feature of such studies, demonstrating striking parallels with a comparable cohort of studies on pedestrians and passengers, has been the integration of existing micro-simulation models with epidemiological models (Manout, 2021).

Summary statistics

As estimated by this review, Transportation journals collectively published nearly 430 studies related to the COVID-19 pandemic. The total production of articles by these journals during the same period of time was 12,715 items (n=6,013 in 2020 and n=6,702 in 2021[2]). Therefore, the extent of pandemic-related studies represents nearly 3.4% of all transport research production during this period of time. The announcement of several Special Issues by transportation journals on topics related to COVID-19 was certainly a factor that contributed to this quick accumulation of papers (Zhang and Hayashi, 2022).

Authors of 71 different countries contributed to this cohort of studies (Figure 2). In the 2020 subset of publications, affiliations to 48 different countries are identifiable. This number increased to 62 countries in 2021. Amongst these, authors of institutes based in China and Canada displayed the highest frequency of collaboration (compared to every other pair of countries) with ten joint publications. Collaborations between Canada and United States (n=5), China and United States (n=5) and Australia and Canada (n=5) were the next most prominent. An interesting observation is the absence of contributions from Brazil in the 2020 subset of publications in contrast to their notable presence in the 2021 subset of publications (Figure 2).

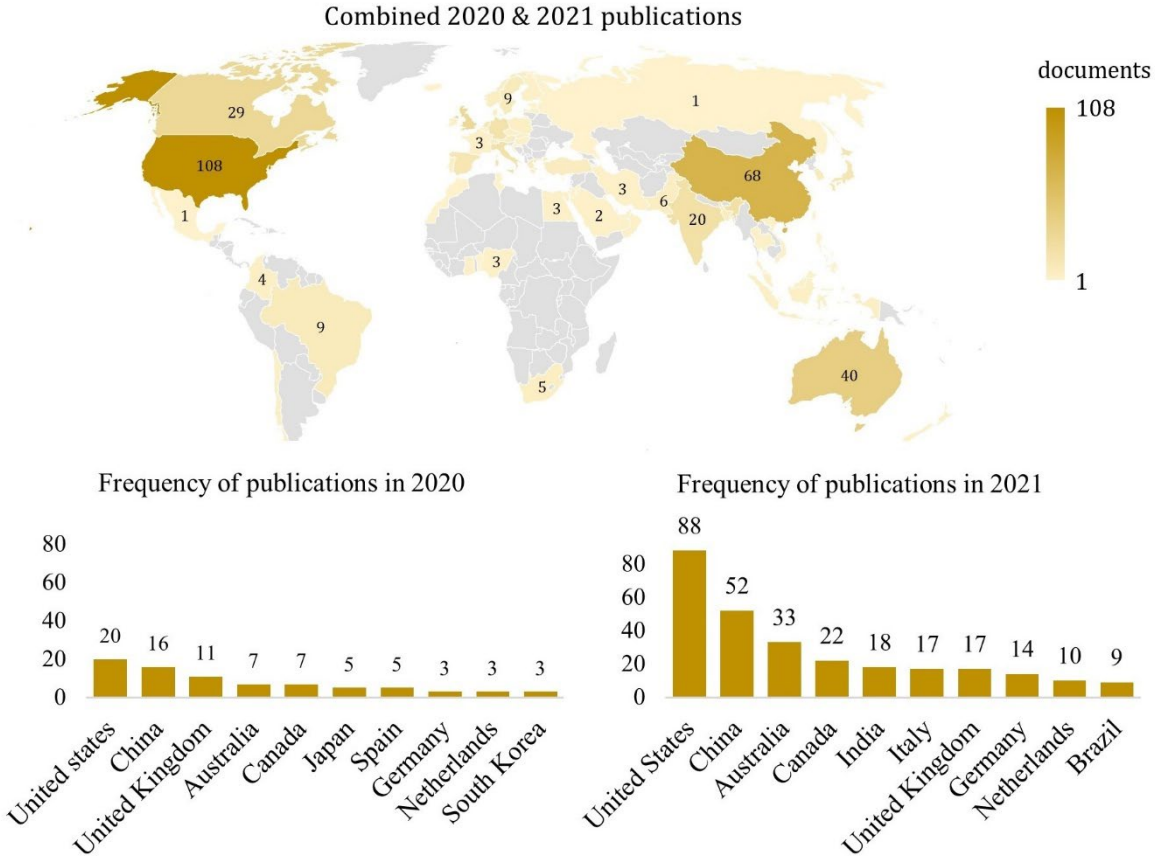

Figure 2 Frequency of contributions from authors of various countries to pandemic-related studies published by Transportation journals during 2020 and 2021, as determined by the author affiliations.

The next analysis compiles all keywords listed by authors in pandemic-related Transportation publications during 2020 and 2021. Recurring keywords (with a minimum of two times occurrence)

[2]The relative growth of the field in 2021 compared to 2020 (nearly 12%) does in fact constitute one of the sharpest rises in the growth of the transport-related literature over the last decade.

are studied. After excluding the most frequent keywords (i.e., COVID-19), "travel behaviour" has been the most frequently used keyword by authors of pandemic studies in Transportation (Figure 3). This is followed by "public transport", "mobility", "social distancing", "lockdown" and "mode choice" (after excluding keywords that merely characterise the context of pandemic). This is also reflected in the categories developed for this review, with "Travel behaviour and mobility changes" being one of the largest categories identified by this review. By combining the keywords that characterise air transport (i.e., "air transport", "air transportation" "airlines", "air travel", "airline industry"), the total frequency of their mention collectively equates that of "public transport", again displaying one of the most recurring themes of pandemic research in Transportation. A comparison between recurring keywords of the subset of 2020 and 2021 studies (Figure 3) clearly shows a diversification of topics in 2021, compared to 2020. In the 2020 subset, only 42 recurring keywords are identifiable, whereas in the 2021 subset, this number increases to 136. The relative frequency of keywords related to air transport is much more noticeable in the 2020 studies compared to 2021, indicative of higher degrees of attention to this topic (relative to other transport topics) during the first year of the pandemic, compared to the second year. In contrast, the relative frequency of the keyword "travel behaviour" increased in the second year of the pandemic.

During 2020 and 2021, a total of 21 Transportation journals published pandemic-related studies (counting those that have at least published three articles related to the pandemic). Among them, *Transportation Research Interdisciplinary Perspectives* (Figure 4) published the largest number of papers, followed by *Transport Policy* and *Journal of Air Transport Management*. These three journals also received the largest number of citations to their COVID-19 publications, compared to other Transportation journals (in terms of the total collective number of citations). The set of studies by *Transportation Research Interdisciplinary Perspectives* related to COVID-19 makes up nearly one-fifth of its entire production during that time (Figure 5). This is understandable considering that these journals published the largest number of papers in this domain. However, an exception is *Transportation Research Part E* that is the seventh in the list of journals based on their quantity of publications, but its count of citations to COVID-19 papers matches that of *Transport Policy* (ranking second in the list of journals based on quantity of papers). This is due to a subset of four COVID-19 articles published by *Transportation Research Part E* that became highly cited (Choi, 2020; Chowdhury et al., 2021; Govindan et al., 2020; Ivanov, 2020). By the end of 2021, these four articles had collectively received 990 citations (according to Scopus records). Overall, the unprecedented attention that was levelled at COVID-19 research in the transportation field during 2020 and 2021 resulted in journals that were active in that domain to receive citation counts to their COVID-19 articles disproportionate to the percentage of their COVID-19 publications. For example, while only around 20% of the content of *Transportation Research Interdisciplinary Perspectives* were COVID-19 papers, nearly 70% of the total citations to the journal during that time period was generated by the subset of its COVID-19 papers (Figure 5). Similarly, while COVID-19 articles made up only 2.8% of the entire production of *Transportation Research Part E*, they generated nearly 25% of the total citations received by the journal. Overall, when the number of citations to the COVID-19 articles of Transportation journals (during 2020-2021) is normalised based on the number of COVID-19 articles published by each journal (Figure 6), *Transportation Research Part E* receives the highest score of 78.1 citations per document, followed by *Transportation Research Interdisciplinary Perspectives* (30.1) and *Transport Reviews* (27.5).

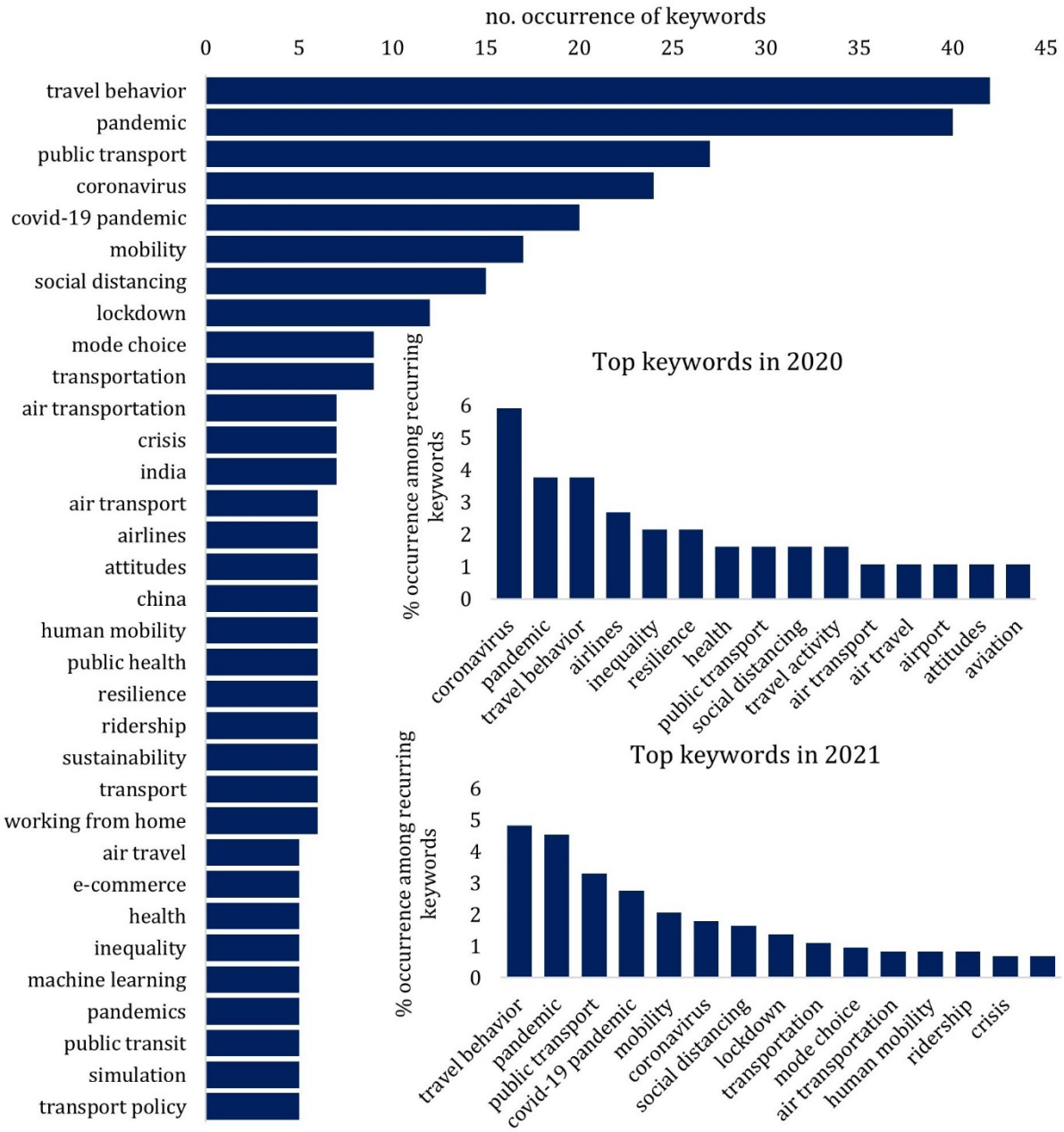

Figure 3 Frequency of the use of recurring keywords in pandemic-related studies published by Transportation journals during 2020 and 2021, as determined by the list of author keywords.

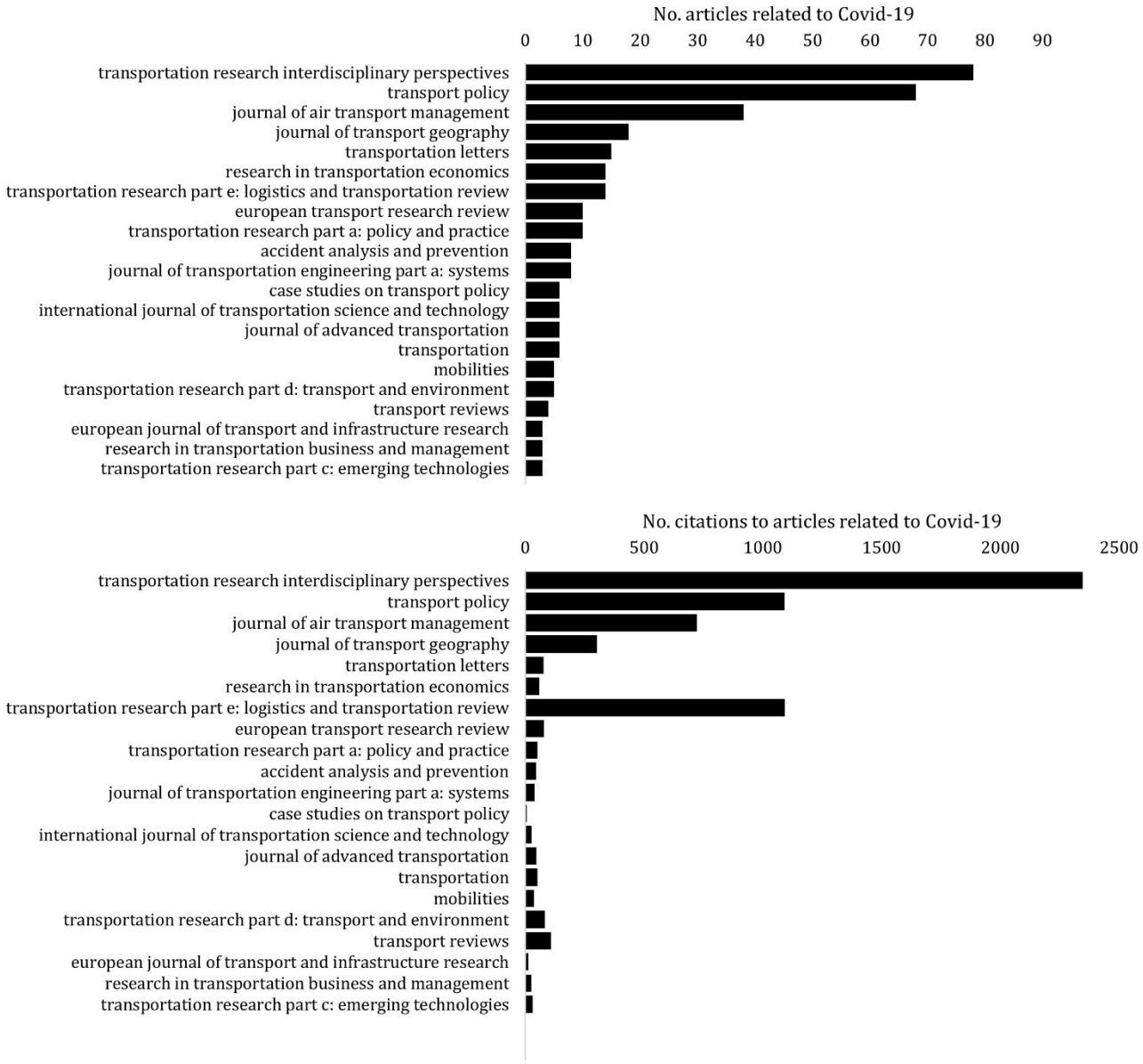

Figure 4 Frequency of publications of COVID-19-related studies by Transportation journals during 2020 and 2021 (top) as well as the number of citations received by each journal to their COVID-19-related articles (bottom).

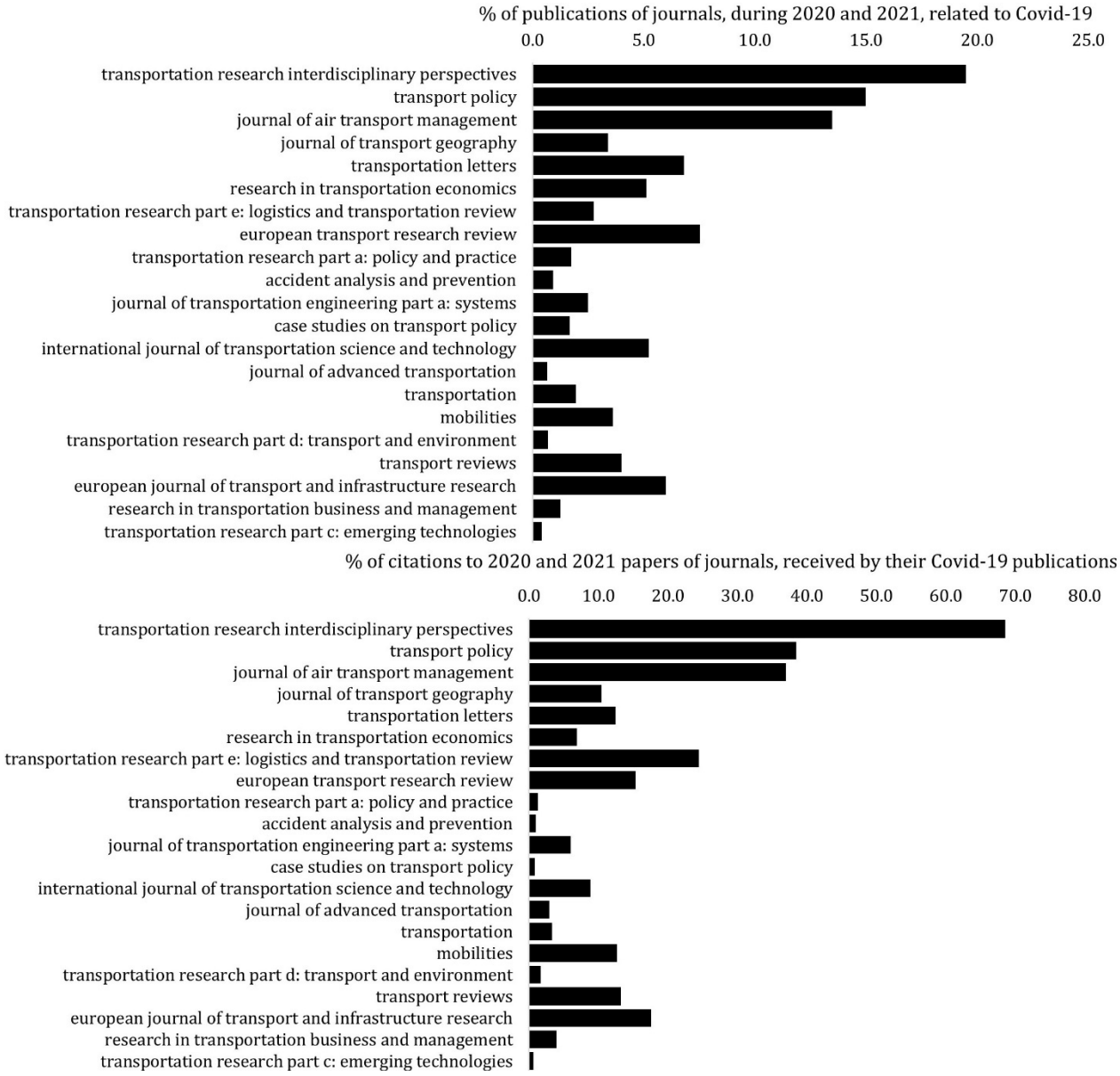

Figure 5 Percentage of publications of COVID-19-related studies by Transportation journals during 2020 and 2021 (top) as well as the percentage of citations received by each journal to their COVID-19-related articles (bottom).

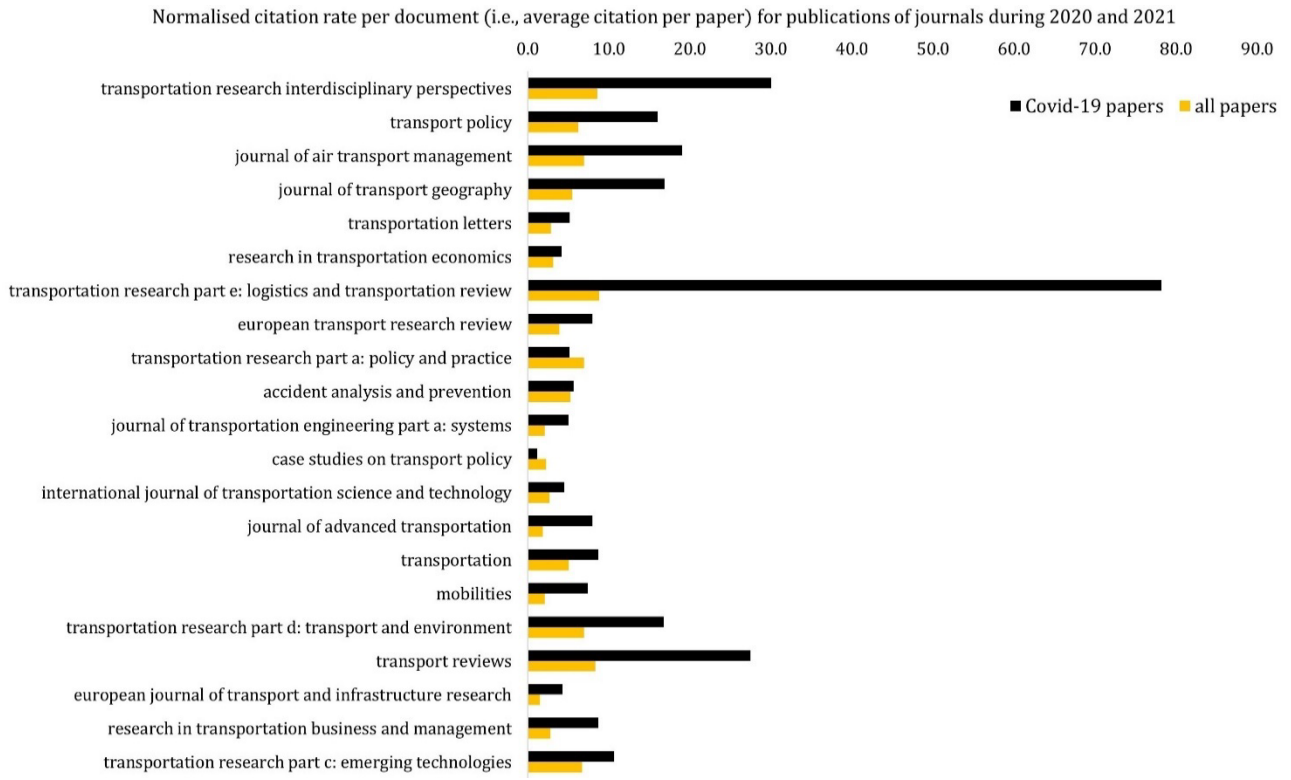

Figure 6 Citations per publication of Transportation journals during 2020-2021, for their overall production as well as the subset of COVID-19 articles.

Table 1 lists the paper that had received the largest counts of citation amongst all COVID-19 papers in Transportation by the end of 2021. The counts of citations to the items listed in Table 1 are not exclusive to citing articles that are themselves COVID-19 or even transportation studies. This reflects a collective count of citation instances that may have been received from outside transportation. For many of the items listed in Table 1, the majority of these citations have occurred in the reference list of non-transportation papers (i.e., those published by journals that are not considered transportation journals).

In order to explore which papers (published pre- or post-pandemic) have been influential in the development of the cohort of transportation papers on COVID-19, the reference lists of all COVID-19 transportation papers were investigated. The documents that have been frequently cited in the reference list of COVID-19 articles were identified and are listed in Table 2. The citation count in this list is reflective of local citation within COVID-19 papers exclusively, i.e., citations received exclusively from the cohort of COVID-19 articles. Interestingly, no pre-pandemic paper of transportation was identified in this list, indicating that COVID-19 papers mostly referred to other COVID-19 articles and did not refer to any particular pre-pandemic transportation paper frequently. In other words, while many conventional methods of transportation studies were revived during the pandemic and were employed for exploring COVID-19-related research questions, no classic reference of transportation literature proved particularly instrumental in the development of this new cohort of the transportation literature. Instead, this cohort formed its own knowledge foundation, one that is specific to itself.

Table 1 Transportation papers on COVID-19 that received the largest counts of citation by the end of 2021.

Author(s) (year)	Title	Journal	Citation
Ivanov (2020)	Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case	Transportation Research Part E	584
De Vos (2020)	The effect of COVID-19 and subsequent social distancing on travel behaviour	Transportation Research Interdisciplinary Perspectives	312
de Haas et al. (2020)	How COVID-19 and the Dutch 'intelligent lockdown' change activities, work and travel behaviour: Evidence from longitudinal data in the Netherlands	Transportation Research Interdisciplinary Perspectives	197
Govindan et al. (2020)	A decision support system for demand management in healthcare supply chains considering the epidemic outbreaks: A case study of coronavirus disease 2019 (COVID-19)	Transportation Research Part E	181
Tirachini and Cats (2020)	COVID-19 and Public Transportation: Current Assessment, Prospects, and Research Needs	Journal of Public Transportation	166
Bucsky (2020)	Modal share changes due to COVID-19: The case of Budapest	Transportation Research Interdisciplinary Perspectives	135
Abdullah et al. (2020)	Exploring the impacts of COVID-19 on travel behaviour and mode preferences	Transportation Research Interdisciplinary Perspectives	126
Beck and Hensher (2020b)	Insights into the impact of COVID-19 on household travel and activities in Australia - The early days under restrictions	Transport Policy	120
Choi (2020)	Innovative "Bring-Service-Near-Your-Home" operations under Corona-Virus (COVID-19/SARS-CoV-2) outbreak: Can logistics become the Messiah?	Transportation Research Part E	120
Shamshiripour et al. (2020)	How is COVID-19 reshaping activity-travel behaviour? Evidence from a comprehensive survey in Chicago	Transportation Research Interdisciplinary Perspectives	110

Table 2 References that received the largest counts of local citations from other COVID-19 papers by the end of 2021.

Author(s) (year)	Title	Journal	Local citation
De Vos (2020)	The effect of Covid-19 and subsequent social distancing on travel behaviour	Transportation Research Interdisciplinary Perspectives	22
Zhang et al. (2020b)	Exploring the roles of high-speed train, air and coach services in the spread of Covid-19 in China	Transport Policy	20
Zhang et al. (2021a)	Covid-19 and transport: findings from a world-wide expert survey	Transport Policy	15
Oum and Wang (2020)	Socially optimal lockdown and travel restrictions for fighting communicable virus including Covid-19	Transport Policy	14
Bucsky (2020)	Modal share changes due to Covid-19: the case of Budapest	Transportation Research Interdisciplinary Perspectives	10
Sun et al. (2020)	How did Covid-19 impact air transportation? a first peek through the lens of complex networks	Journal of Air Transport Management	10
Beck and Hensher (2020b)	Insights into the impact of Covid-19 on household travel and activities in Australia – the early days under restrictions	Transport Policy	9
de Haas et al. (2020)	How Covid-19 and the Dutch 'intelligent lockdown' change activities, work and travel behaviour: evidence from longitudinal data in the Netherlands	Transportation Research Interdisciplinary Perspectives	9
Zhang (2020)	Transport policymaking that accounts for Covid-19 and future public health threats: a PASS approach	Transport Policy	9
Abdullah et al. (2020)	Exploring the impacts of COVID-19 on travel behaviour and mode preferences	Transportation Research Interdisciplinary Perspectives	8

Discussions and conclusions

The transportation sector has, in many ways, epitomised many of the 'good and bad' consequences of the COVID-19 pandemic. Although at the time of writing we are only two years out from the beginning of the pandemic, and there are signs of recovery, the mobility landscape has changed to a sufficient extent that it is likely, in time, that the memories of a pre-COVID-19 society will shift into an historical period that we remember as quite different to the circumstances experienced today under a 'new' or 'next' normal. We can best describe the coming out of the early years of the pandemic as a feast of structural responses that are already starting to redefine some of the key drivers of the next few years and beyond. We often talk of the unintended consequences of the pandemic, and there are many as we have shown in this paper, but we cannot and should not want to turn the clock back, but ask ourselves what might we do to ensure that we learn and benefit from this period of massive upheaval in the way we live our lives and businesses go about delivering services?

Lockdowns are an interesting phenomenon that might be seen as a disaster for the economic and social wellbeing of society. However, they forced on us a number of real-world experiments that have delivered some good outcomes. An example is the growing incidence of working from home (WFH) and the support it has garnered from both employees and employers, given the slight gains in productivity, with variations dependent, in the main, on occupation and the need or otherwise to be physically involved in work. We might describe 'WFH to some extent' as the most impactful positive transport policy instrument we have had out of the pandemic, especially for land passenger transport, since the invention of the internal combustion engine resulted in improved mobility for the masses. The pandemic has highlighted a recognition that much more can and should be done at the local (or suburban and indeed regional) level to improve accessibility and mobility, refocussing on active travel (walking, cycling) and how this translates into reduced commuting distances and the start of an opportunity to deliver the 20-minute city. We are starting to see a greater commitment by governments in many countries who are questioning (but not yet deciding) the need for some of the long-term infrastructure investments that support longer distance metropolitan travel by car and public transport.

There are many ongoing challenges to governments, to the broad base of employers, and even to households, as they work out how best to encapsulate the non-stigmatised WFH future (Beck and Hensher, 2021). There is enough accumulating evidence in other studies, that working from home and working near home (WNH), will be embedded at the centre of the 'next' or 'new' normal. While the timing of this is not clear, in the sense of a stable level that can be used in future planning and proofing, there are signs that adjustments made through experience, often without choice, and through outcomes that have proven on balance to be very attractive to both employees and employers where working all of the time on-site is not necessary or valuable, will reinforce a regular pattern of WFH and WNH that is significantly greater than pre-COVID-19 levels. The often suggested metric of one to two days a week on average, seems to be reinforced by almost all studies reported in this paper. As hybrid working becomes more structured, and technologies and work patterns better support the mix between WFH and work "on-site", we can expect productivity gains to be enforced as workers and workplaces gain the benefits of better flexibility, but also better face-to-face contact.

The implications for funding of infrastructure, re-prioritising land use plans, growing new office settings which include satellite offices, and what the future office environment might be are profound (Ramani and Bloom, 2021). A spinoff impact that is raising a challenge is the reduction in the number of office workers commuting daily and especially to the central business districts of many cities.

Recent research by Hensher et al. (2022b) concludes that the range of the percentage of days working that are WFH in Sydney suggests a potential drop in the amount of office space required at the main office of between 85.2% and 62.8%. If we work with what appears to be the most likely scenario of one to two days WFH per week for many occupations, Hensher et al. (2022b) predict a reduction in the percentage of office space compared to pre-COVID-19 of 79.6% for an average of one day WFH and 72.1% for an average of two days WFH. The decline of 20% to 28% in 2023 relates reasonably well to an occupancy rate in February 2022 of 18% for the Sydney metropolitan area[3].

Many cities have been bracing for this in their forward budgets; but their projections for the quantum of people who will continue to work from home is almost certain to underestimate the magnitude of the shift. Philadelphia, for example, assumed a permanent loss of 15% of the non-resident wage tax base in its projections, according to an analysis by the Philadelphia Office of the Controller last July. San Francisco, in a five-year financial plan published in January, estimates that office workers will permanently telecommute about 15% of the time in the fiscal year 2025-2026[4].

On methods, a number of researchers working with government agencies have revised strategic transport models in both metropolitan and regional settings in order to adjust travel demand forecasts in the presence of WFH. This is a complex process that recognises that WFH influences directly and indirectly many of the travel and location decision that are made in the passenger and freight sectors. Now that WFH has become non-stigmatised, failure to adjust traffic forecasts for WFH is a potentially serious flaw in strategic transport models. One important finding by Hensher et al. (2021a) is the revision that needs to occur to the value of travel time savings which represents the most important user benefit (as a standalone or generalised cost metric), used in travel demand forecasting and transport appraisal. They found, using revealed preference data from real markets in Sydney, that the value of commuting time, on average, is 15% higher (given the distribution of the number of days predicted to WFH) than pre-COVID-19. While there might be fewer commuting trips per person, the net effect on overall travel time benefits might increase or decrease depending on the average number of weekly commuting trips compared to pre-COVID-19. Importantly, relying on stated preference data and failing to build in the incidence of actual days WFH into the models will not provide empirically relevant estimates on changes in VoT pre- and during COVID-19.

In this paper we have discussed the health impacts of COVID in general and specifically in the context of public transport which has suffered an enormous decline in patronage, typically well below 50% and recovering slowly to estimates in 2022 around 60-70%. This decline in public transport ridership could be due to several reasons including lockdown policies, remote work policies, and changes in transportation modes. Sociodemographic factors, transportation-related attributes (e.g., the availability of alternative modes), perception of the risk, and health-related factors can significantly affect the mode choice and travel behaviour. Public transportation agencies have adapted different strategies to reduce the operational costs, including reducing the number of lanes, reducing the service, closing selected stations, etc. The nervousness in using public transport in the context of bio-security risk has been studied extensively with the main conclusion being one of poor messaging in the early days of the pandemic resulting in a build of negative sentiment. Beck et al. (2022) have looked into the barriers to public transport use and actions required to restore confidence as

[3] https://www.commercialrealestate.com.au/news/workers-trickle-back-to-offices-but-cbds-remain-critically-underpopulated-1130458/ 20 May 2022.
[4] https://www.bloomberg.com/news/articles/2022-02-28/remote-work-seen-more-persistent-than-u-s-city-planners-expect 28 February 2021.

summarised in Figure 7. Most commentators suggest that public transport is unlikely to recover to levels higher than 70% of pre-COVID levels for many years.

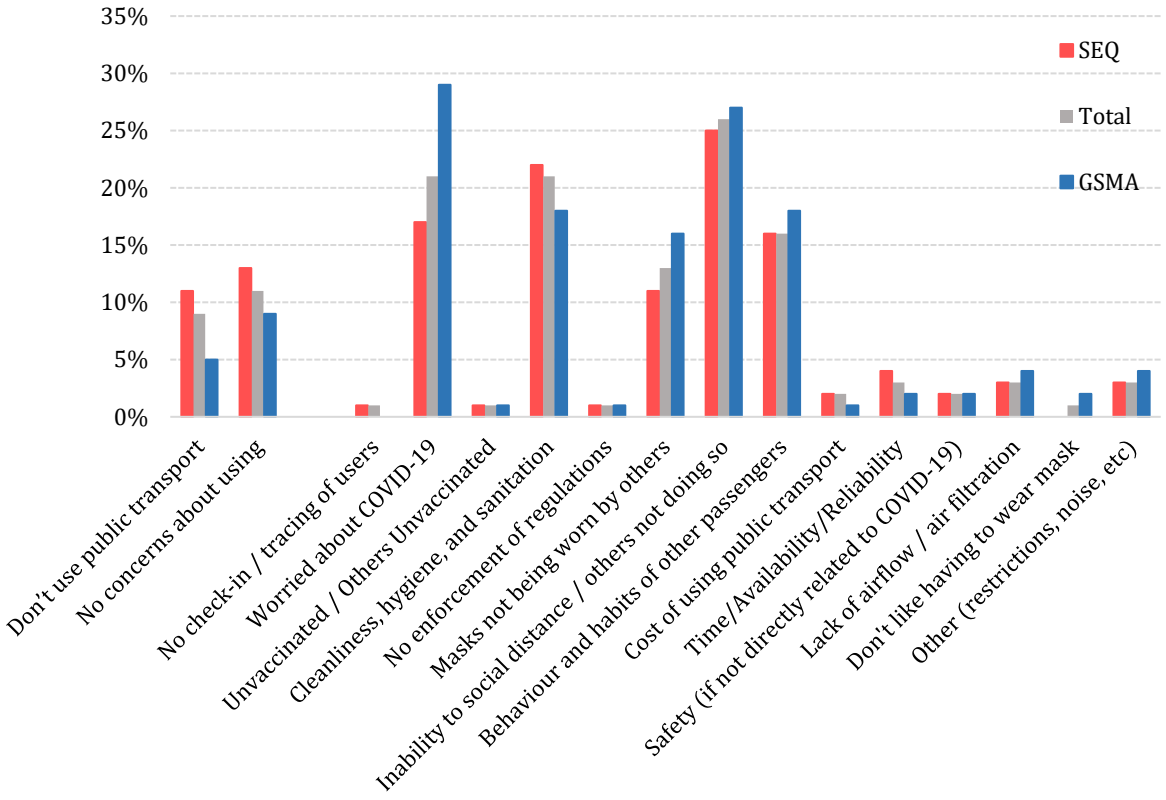

Figure 7 Commonly stated barriers to public transport use.

This nervousness also impacted on ride share, with people less likely to use shared mobility (especially in a confined area) preferring to use personal vehicles. In contrast, for bike-sharing, several studies reported that bike-sharing services returned to the normal condition faster than other shared mobility modes. It seems that the overall rate of active mobility ridership has increased during the pandemic period. However, different factors such as the proportion of remote working, trip purpose, trip distance, time and place of use, and users' socio-demographic characteristics should be considered to evaluate changes in active mobility ridership. The extent of substitution of users' primary mode by active mobility is varied in different studies.

One expected consequence of measures taken to curb the spread of COVID-19 was a noticeable reduction in traffic volumes on the roads. Traffic density fell in all nations that instituted lockdowns which significantly suppressed mobility. It also fell in nations resisting such measures. As a direct consequence of reduced traffic volumes, most nations experienced a reduction in the incidence of road crashes. A review of more than 100 research studies on global road crashes, indicated that this reduction varied considerably, ranging, for example, from 26% in Canada, to 74% in France, and 11 to 58% in the United States (Buchanan, 2022). This reduction in crash frequency was accompanied, however, by a dramatic increase in the severity of road crashes and fatalities. In Spain, for example, the fraction of deadly crashes increased five-fold over the first year of the COVID-19 pandemic. Similarly, crashes involving extreme speeds became three times more likely in the United Kingdom. In the United States, numbers increased 65% in Boston and 167% in New York. They nearly quadrupled in Chicago. The 'speed effect' is the increase in traffic fatalities due to higher average traffic speeds. With many drivers WFH, the drop in traffic resulted in higher road speeds in the

absence of the high levels of traffic congestion, and hence exposure to higher risks of crashes and more severe one. This might be best described as an unintended negative consequence of the pandemic.

From a supply chain perspective, the pandemic has significantly disrupted the last mile delivery of goods and services – something that continues to be noticed/criticised on a daily basis by people and the mainstream media. Growth and innovation in last mile delivery had been strong for a number of years. Then came the pandemic. The steady expansion gave way to a sudden chaotic explosion in demand. The challenges were further amplified by supply shortages due to COVID-19 restrictions and new operational guidelines/policies. This is an ongoing challenge which is creating numerous research opportunities – particularly collaborative opportunities for applied research.

Pedestrians, foot traffic and passengers has come to the fore during the pandemic. Many studies have focused on integrating conventional pedestrian movement models (e.g., social force) with epidemiological models to simulate risk of disease transmission. It is unclear, however, whether the aim of these efforts should be on estimating relative risk of transmission (i.e., comparing two scenarios) or absolute risk of transmission. These two have vastly different modelling requirements. The latter requires more modelling nuance and expertise regarding epidemiological aspects that pedestrian modellers and transportation researchers may not necessarily have. The potential role of computer-vision and artificial intelligence (AI) in pedestrian research (e.g., automatic detection of social distancing violation) during COVID-19 did not noticeably materialise in transportation research. Perhaps because this is not an area where transportation researchers are particularly adept.

The majority of maritime studies focused on examining the impacts of the COVID-19 pandemic on various sectors and components of the maritime industry i.e., shipping and port, their markets and corresponding responses. A consistent finding across these studies is that the pandemic has resulted in negative impacts i.e., declined demand volumes, reduced network connectivity, etc. This reaffirms an important characteristic of shipping i.e., its demand is derived from world trade, and thus has always been impacted by various socio-economic events, in which pandemics such as COVID-19 is an example.

Flexibility through capacity management has been used as a robust resilience strategy in the maritime industry, both in the shipping and port sectors. While this may not be a new strategy in transport, it would be interesting to examine in future comparative studies on how it has been deployed and the level of outcomes across sectors, as well as in comparison with other resilience strategies.

Shipping and the maritime sector in particular have been disrupted away from just in time and fixed pricing to variable prates and uncertainty in freight movements. The main impacts of COVID-19 on shipping have been the slowing of supply chains. Driver shortages and loss of warehouse productivity have led to cargo spending more time in containers, leading to a shortage of containers and ports running out of yard space. Loss of port efficiency has led to port congestion, containers spending more time on ships and therefore a shortage of shipping capacity. Freight rates have increased by a factor ten as exporters bid for empty containers, which are now on ships or in ports rather than being made available to exporters. Container shipping lines are making bumper profits.

There has also been a significant increase in crew distress. Crew changes have become more difficult due to travel restrictions and bans, leading to seafarers exceeding their contract durations and spending more than the maximum allowed 11 months at sea. Being on a ship in a pandemic is about

the best place to be as you are socially distanced (until a crew mate gets infected). The problem is you cannot get off the ship!

The COVID-19 related air transport literature has exposed the ill-preparedness of airlines and airports, how vital government support was and vital and a good investment as for the first time it became clear how vital aviation is for global travel and supply chains The airline industry has been found to be agile, with new business models such as ultra-long-haul emerging. The industry is changing fast, and it is still a fluid situation, but more recent papers have established that some COVID-19 patterns have resulted in permanent changes in travel or freight demand behaviour (Merkert et al., 2022).

Our final conclusion is that the pandemic did in fact create many unprecedented real-life problems for transportation researchers across the board. The transportation community embraced those challenges and mobilised efforts to address these problems as swiftly as possible. However, one cannot help but notice that the urgency with which the research community responded—in terms of formulating, executing, disseminating and even peer reviewing these research—may have, at least in cases, come at the cost of rigour. The topical nature of COVID-19 research made it also acceptable to publish research using old-fashioned methodologies that may have otherwise not been publishable anymore in the transportation field on any other topic. Our review demonstrated the unusual citation counts that COVID-19 related studies—and their respective authors and journals—typically received compared to average publications in transportation. In fact, future investigations can potentially look into the trends in citation accumulation of transportation authors who published research related to COVID-19 as compared to those who did not, to better quantify and document this effect. It is reasonable to assume that the urgency of the problems to be addressed as well as the motivations that researchers had for capitalising on the trendy nature of this research have both contributed to such swift accumulation of studies in a short period of time. Future studies could investigate which of these studies will likely have lasting effects on the future of transportation research and which effects were more transient and short-lived. We believe that this large-scope review can facilitate such future investigations by documenting what was done and achieved during the first two years of the pandemic in transportation research.

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Zhang, Y.H., Zhang, A.M., 2021. COVID-19 and bailout policy: The case of Virgin Australia. *Transport Policy* 114, 174-181.
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Zhou, H.Y., Wang, Y.C., Huscroft, J.R., Bai, K.L., 2021a. Impacts of COVID-19 and anti-pandemic policies on urban transport-an empirical study in China. *Transport Policy* 110, 135-149.
Zhou, Y.M., Kundu, T., Qin, W., Goh, M., Sheu, J.B., 2021b. Vulnerability of the worldwide air transportation network to global catastrophes such as COVID-19. *Transportation Research Part E-Logistics and Transportation Review* 154.
Zhou, Y.R., Liu, X.C., Grubesic, T., 2021c. Unravel the impact of COVID-19 on the spatio-temporal mobility patterns of microtransit. *Journal of Transport Geography* 97.
Zhu, C.L., Wu, J.P., Liu, M.Y., Wang, L.Y., Li, D.W., Kouvelas, A., 2021. Recovery preparedness of global air transport influenced by COVID-19 pandemic: Policy intervention analysis. *Transport Policy* 106, 54-63.
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Zuo, F., Gao, J.Q., Kurkcu, A., Yang, H., Ozbay, K., Ma, Q.Y., 2021. Reference-free video-to-real distance approximation-based urban social distancing analytics amid COVID-19 pandemic. *Journal of Transport & Health* 21.

Appendix—The list of reviewed COVID-related publications (2020-2021) within each category of transportation research

Author(s) (year)	Title	Journal
	Air transport	
Li (2021)	Air Emergency Transport under COVID-19: Impact, Measures, and Future	Journal of Advanced Transportation
Abate et al. (2020)	Government support to airlines in the aftermath of the COVID-19 pandemic	Journal of Air Transport Management
Akbar and Kisilowski (2020)	To bargain or not to bargain: Airlines, legitimacy and nonmarket strategy in a COVID-19 world	Journal of Air Transport Management
Albers and Rundshagen (2020)	European airlines' strategic responses to the COVID-19 pandemic (January-May, 2020)	Journal of Air Transport Management
Atems and Yimga (2020)	Quantifying the impact of the COVID-19 pandemic on US airline stock prices	Journal of Air Transport Management
Bauer et al. (2020)	Ultra Long-Haul: An emerging business model accelerated by COVID-19	Journal of Air Transport Management

Author(s) (year)	Title	Journal
Brown and Kline (2020)	Exogenous shocks and managerial preparedness: A study of US airlines' environmental scanning before the onset of the COVID-19 pandemic	Journal of Air Transport Management
Choi (2021a)	Changes in airport operating procedures and implications for airport strategies post-COVID-19	Journal of Air Transport Management
Czerny et al. (2021)	Post pandemic aviation market recovery: Experience and lessons from China	Journal of Air Transport Management
Dabachine et al. (2020)	Strategic design of precautionary measures for airport passengers in times of global health crisis Covid 19: Parametric modelling and processing algorithms	Journal of Air Transport Management
Dube et al. (2021)	COVID-19 pandemic and prospects for recovery of the global aviation industry	Journal of Air Transport Management
Forsyth et al. (2020)	Covid-19, the collapse in passenger demand and airport charges	Journal of Air Transport Management
Gossling (2020)	Risks, resilience, and pathways to sustainable aviation: A COVID-19 perspective	Journal of Air Transport Management
Graham et al. (2020)	Attitudes of ageing passengers to air travel since the coronavirus pandemic	Journal of Air Transport Management
Gudmundsson et al. (2021)	Forecasting temporal world recovery in air transport markets in the presence of large economic shocks: The case of COVID-19	Journal of Air Transport Management
Hanson et al. (2022)	How do changes in economic activity affect air passenger traffic? The use of state-dependent income elasticities to improve aviation forecasts	Journal of Air Transport Management
Hou et al. (2021)	Hub airport slot Re-allocation and subsidy policy to speed up air traffic recovery amid COVID-19 pandemic --- case on the Chinese airline market	Journal of Air Transport Management
Kierzkowski and Kisiel (2020)	Simulation model of security control lane operation in the state of the COVID-19 epidemic	Journal of Air Transport Management
Kim and Sohn (2022)	Passenger, airline, and policy responses to the COVID-19 crisis: The case of South Korea	Journal of Air Transport Management
Kurt (2021)	Diffusion of the Airport Health Accreditation Program in the COVID-19 period: An Assessment with Institutional Logic and Legitimacy Approach	Journal of Air Transport Management
Lamb et al. (2021)	A qualitative analysis of social and emotional perspectives of airline passengers during the COVID-19 pandemic	Journal of Air Transport Management
Lamb et al. (2020)	Factors that predict passengers willingness to fly during and after the COVID-19 pandemic	Journal of Air Transport Management
Li (2020)	A SWOT analysis of China's air cargo sector in the context of COVID-19 pandemic	Journal of Air Transport Management
Lin and Zhang (2021)	Investigating air travellers' travel motivation during a pandemic crisis	Journal of Air Transport Management
Linden (2021)	Pandemics and environmental shocks: What aviation managers should learn from COVID-19 for long-term planning	Journal of Air Transport Management
Macilree and Duval (2020)	Aeropolitics in a post-COVID-19 world	Journal of Air Transport Management
Maneenop and Kotcharin (2020)	The impacts of COVID-19 on the global airline industry: An event study approach	Journal of Air Transport Management
Massaro and Rossetti (2021)	Comparing proximity for couples of close airports. Case studies on city-airports in the pre COVID-19 era	Journal of Air Transport Management
Miani et al. (2021)	The impact of the COVID-19 pandemic on current tertiary aviation education and future careers: Students' perspective	Journal of Air Transport Management
Naboush and Alnimer (2020)	Air carrier's liability for the safety of passengers during COVID-19 pandemic	Journal of Air Transport Management
Pereira and de Mello (2021)	Efficiency evaluation of Brazilian airlines operations considering the Covid-19 outbreak	Journal of Air Transport Management
Salari et al. (2020)	Social distancing in airplane seat assignments	Journal of Air Transport Management
Samanci et al. (2021)	Focusing on the big picture while observing the concerns of both managers and passengers in the post-covid era	Journal of Air Transport Management
Santos et al. (2021)	Testing the differentiated impact of the COVID-19 pandemic on air travel demand considering social inclusion	Journal of Air Transport Management
Scheiwiller and Zizka (2021)	Strategic responses by European airlines to the Covid-19 pandemic: A soft landing or a turbulent ride?	Journal of Air Transport Management
Schultz et al. (2020)	Future aircraft turnaround operations considering post-pandemic requirements	Journal of Air Transport Management
Serrano and Kazda (2020)	The future of airports post COVID-19	Journal of Air Transport Management
Shaban et al. (2021)	A novel model to manage air cargo disruptions caused by global catastrophes such as Covid-19	Journal of Air Transport Management
Sun et al. (2020)	How did COVID-19 impact air transportation? A first peek through the lens of complex networks	Journal of Air Transport Management
Sun et al. (2021f)	COVID-19 pandemic and air transportation: Successfully navigating the paper hurricane	Journal of Air Transport Management
Tanriverdi et al. (2020)	What can we learn from the JATM literature for the future of aviation post Covid-19? - A bibliometric and visualization analysis	Journal of Air Transport Management
Tisdall and Zhang (2020)	Preparing for 'COVID-27': Lessons in management focus - An Australian general aviation perspective	Journal of Air Transport Management
Truong (2021)	Estimating the impact of COVID-19 on air travel in the medium and long term using neural network and Monte Carlo simulation	Journal of Air Transport Management
Tuchen et al. (2020)	Airport user experience unpacked: Conceptualizing its potential in the face of COVID-19	Journal of Air Transport Management

Author(s) (year)	Title	Journal
Warnock-Smith et al. (2021)	Impact of COVID-19 on air transport passenger markets: Examining evidence from the Chinese market	Journal of Air Transport Management
Xue et al. (2021)	Impacts of COVID-19 on aircraft usage and fuel consumption: A case study on four Chinese international airports	Journal of Air Transport Management
Yu and Chen (2021)	The effect of aviation responses to the control of imported COVID-19 cases	Journal of Air Transport Management
Zhang et al. (2021d)	The impact of COVID-19 on airline passenger travel behavior: An exploratory analysis on the Chinese aviation market	Journal of Air Transport Management
Zhang et al. (2020a)	Measuring imported case risk of COVID-19 from inbound international flights - A case study on China	Journal of Air Transport Management
de Souza et al. (2021)	Airports, highways and COVID-19: An analysis of spatial dynamics in Brazil	Journal of Transport & Health
Bombelli (2020)	Integrators' global networks: A topology analysis with insights into the effect of the COVID-19 pandemic	Journal of Transport Geography
Budd et al. (2021)	An assessment of air passenger confidence a year into the COVID-19 crisis: A segmentation analysis of passengers in Norway	Journal of Transport Geography
Deng et al. (2022)	An analysis of the Chinese scheduled freighter network during the first year of the COVID-19 pandemic	Journal of Transport Geography
Suau-Sanchez et al. (2020)	An early assessment of the impact of COVID-19 on air transport: Just another crisis or the end of aviation as we know it?	Journal of Transport Geography
Wang et al. (2021b)	Geovisualizing cancelled air and high-speed train services during the outbreak of COVID-19 in China	Journal of Transport Geography
Lin and Yeoh (2021)	Pathological (Im)mobilities: managing risk in a time of pandemics	Mobilities
Budd et al. (2020)	European airline response to the COVID-19 pandemic - Contraction, consolidation and future considerations for airline business and management	Research in Transportation Business and Management
Byrnes et al. (2021)	The effect of a safety crisis on safety culture and safety climate: The resilience of a flight training organization during COVID-19	Transport Policy
Li et al. (2021b)	Spatiotemporal variation of the worldwide air transportation network induced by COVID-19 pandemic in 2020	Transport Policy
Nakamura and Managi (2020)	Airport risk of importation and exportation of the COVID-19 pandemic	Transport Policy
Sun et al. (2021d)	Technological and educational challenges towards pandemic-resilient aviation	Transport Policy
Sun et al. (2021e)	Vaccination passports: Challenges for a future of air transportation	Transport Policy
Sun et al. (2021c)	On the degree of synchronization between air transport connectivity and COVID-19 cases at worldwide level	Transport Policy
Tisdall et al. (2021)	COVID-19 impacts on general aviation - Comparative experiences, governmental responses and policy imperatives	Transport Policy
Zhang and Zhang (2021)	COVID-19 and bailout policy: The case of Virgin Australia	Transport Policy
Zhu et al. (2021)	Recovery preparedness of global air transport influenced by COVID-19 pandemic: Policy intervention analysis	Transport Policy
Al-Shihabi et al. (2021)	COVID-19 repatriation programs — Classification and optimization models	Transportation Research Interdisciplinary Perspectives
Arora et al. (2021)	Airport pandemic response: An assessment of impacts and strategies after one year with COVID-19	Transportation Research Interdisciplinary Perspectives
Calderon-Tellez and Herrera (2021)	Appraising the impact of air transport on the environment: Lessons from the COVID-19 pandemic	Transportation Research Interdisciplinary Perspectives
Hotle and Mumbower (2021)	The impact of COVID-19 on domestic U.S. air travel operations and commercial airport service	Transportation Research Interdisciplinary Perspectives
Istijanto (2021)	Impacts of the COVID-19 pandemic on airline passengers' recovery satisfaction: An experimental study	Transportation Research Interdisciplinary Perspectives
Jarry et al. (2021)	Flight safety during Covid-19: A study of Charles de Gaulle airport atypical energy approaches	Transportation Research Interdisciplinary Perspectives
Monmousseau et al. (2020)	Impact of Covid-19 on passengers and airlines from passenger measurements: Managing customer satisfaction while putting the US Air Transportation System to sleep	Transportation Research Interdisciplinary Perspectives
Sobieralski (2020)	COVID-19 and airline employment: Insights from historical uncertainty shocks to the industry	Transportation Research Interdisciplinary Perspectives
Sokadjo and Atchadé (2020)	The influence of passenger air traffic on the spread of COVID-19 in the world	Transportation Research Interdisciplinary Perspectives
Wild (2021)	Corporate social responsibility, cost structures, and COVID-19: Impact of passenger behavior on business models	Transportation Research Interdisciplinary Perspectives
Yimga (2021)	The airline on-time performance impacts of the COVID-19 pandemic	Transportation Research Interdisciplinary Perspectives
Sun et al. (2021b)	Delayed reaction towards emerging COVID-19 variants of concern: Does history repeat itself?	Transportation Research Part A -Policy and Practice

Author(s) (year)	Title	Journal
Kallbekken and Saelen (2021)	Public support for air travel restrictions to address COVID-19 or climate change	Transportation Research Part D-Transport and Environment
Amankwah-Amoah (2020)	Note: Mayday, Mayday, Mayday! Responding to environmental shocks: Insights on global airlines ' responses to COVID-19	Transportation Research Part E-Logistics and Transportation Review
Li et al. (2021c)	Impact of entry restriction policies on international air transport connectivity during COVID-19 pandemic	Transportation Research Part E-Logistics and Transportation Review
Zhou et al. (2021b)	Vulnerability of the worldwide air transportation network to global catastrophes such as COVID-19	Transportation Research Part E-Logistics and Transportation Review
Atay et al. (2021)	Investigation of Breaking Points in the Airline Industry with Airline Optimization Studies Through Text Mining before the COVID-19 Pandemic	Transportation Research Record
Dray and Schafer (2021)	Initial Long-Term Scenarios for COVID-19's Impact on Aviation and Implications for Climate Policy	Transportation Research Record
Manca et al. (2021)	Will We Fly Again? Modeling Air Travel Demand in light of COVID-19 through a London Case Study	Transportation Research Record
Milne et al. (2021)	Minimizing health risks as a function of the number of airplane boarding groups	Transportmetrica B-Transport Dynamics
Salari et al. (2021)	Social distancing in airplane seat assignments for passenger groups	Transportmetrica B-Transport Dynamics
Schultz and Soolaki (2021)	Optimized aircraft disembarkation considering COVID-19 regulations	Transportmetrica B-Transport Dynamics
Maritime transport		
Tai et al. (2021)	Impact of COVID-19 on Port Production and Operation Based on System Dynamics: A Case Study of Shanghai Port in China	Journal of Advanced Transportation
Huq et al. (2021)	The effect of covid-19 on inland waterway accidents in bangladesh	Journal of Transport & Health
Cullinane and Haralambides (2021)	Global trends in maritime and port economics: the COVID-19 pandemic and beyond	Maritime Economics & Logistics
Notteboom et al. (2021)	Disruptions and resilience in global container shipping and ports: the COVID-19 pandemic versus the 2008-2009 financial crisis	Maritime Economics & Logistics
Notteboom and Haralambides (2020)	Port management and governance in a post-COVID-19 era: quo vadis?	Maritime Economics & Logistics
Russell et al. (2021)	Managing supply chain uncertainty by building flexibility in container port capacity: a logistics triad perspective and the COVID-19 case	Maritime Economics & Logistics
Kamal et al. (2021)	Stock market reactions of maritime shipping industry in the time of COVID-19 pandemic crisis: an empirical investigation	Maritime Policy & Management
Koyuncu et al. (2021)	Forecasting COVID-19 impact on RWI/ISL container throughput index by using SARIMA models	Maritime Policy & Management
Guerrero et al. (2022)	The container transport system during Covid-19: An analysis through the prism of complex networks	Transport Policy
Narasimha et al. (2021)	Impact of COVID-19 on the Indian seaport transportation and maritime supply chain	Transport Policy
Yuen et al. (2021)	Cruise transport service usage post COVID-19: The health belief model application	Transport Policy
Holland et al. (2021)	Cruising through a pandemic: The impact of COVID-19 on intentions to cruise	Transportation Research Interdisciplinary Perspectives
Ito et al. (2020)	The cruise industry and the COVID-19 outbreak	Transportation Research Interdisciplinary Perspectives
Michail and Melas (2020)	Shipping markets in turmoil: An analysis of the Covid-19 outbreak and its implications	Transportation Research Interdisciplinary Perspectives
Silva (2021)	An overview of the impact of COVID-19 on the cruise industry with considerations for Florida	Transportation Research Interdisciplinary Perspectives
Supply chain and distribution services		
Lemke et al. (2020)	Syndemic frameworks to understand the effects of COVID-19 on commercial driver stress, health, and safety	Journal of Transport & Health
Bastug and Yercan (2021)	An explanatory approach to assess resilience: An evaluation of competitive priorities for logistics organizations	Transport Policy
Calatayud et al. (2022)	Containing the spatial spread of COVID-19 through the trucking network	Transport Policy
Kawasaki et al. (2022)	The use of e-commerce and the COVID-19 outbreak: A panel data analysis in Japan	Transport Policy
Kunovjanek and Wankmuller (2021)	Containing the COVID-19 pandemic with drones-Feasibility of a drone enabled back-up transport system	Transport Policy
Ozden and Celik (2021)	Analyzing the service quality priorities in cargo transportation before and during the Covid-19 outbreak	Transport Policy
Sanchez-Diaz et al. (2021)	Assessing the inequalities in access to online delivery services and the way COVID-19 pandemic affects marginalization	Transport Policy
Yang et al. (2021a)	Dynamic impacts of COVID-19 pandemic on the regional express logistics: Evidence from China	Transport Policy

Author(s) (year)	Title	Journal
Swanson and Suzuki (2020)	COVID-19 Carves New Facets of Supply Chain Disruption	Transportation Journal
Ozkan and Atli (2021)	Transporting COVID-19 testing specimens by routing unmanned aerial vehicles with range and payload constraints: the case of Istanbul	Transportation Letters
Zannat et al. (2021)	The tale of two countries: modeling the effects of COVID-19 on shopping behavior in Bangladesh and India	Transportation Letters
Chen et al. (2020)	Vehicle routing problem of contactless joint distribution service during COVID-19 pandemic	Transportation Research Interdisciplinary Perspectives
Grida et al. (2020)	Evaluate the impact of COVID-19 prevention policies on supply chain aspects under uncertainty	Transportation Research Interdisciplinary Perspectives
Loske (2020)	The impact of COVID-19 on transport volume and freight capacity dynamics: An empirical analysis in German food retail logistics	Transportation Research Interdisciplinary Perspectives
Srivatsa Srinivas and Marathe (2021)	Moving towards “mobile warehouse”: Last-mile logistics during COVID-19 and beyond	Transportation Research Interdisciplinary Perspectives
Sun et al. (2021a)	A simulation-based analysis for effective distribution of COVID-19 vaccines: A case study in Norway	Transportation Research Interdisciplinary Perspectives
Unnikrishnan and Figliozzi (2021)	Exploratory analysis of factors affecting levels of home deliveries before, during, and post- COVID-19	Transportation Research Interdisciplinary Perspectives
Unnikrishnan and Figliozzi (2021)	Exploratory analysis of factors affecting levels of home deliveries before, during, and post- COVID-19	Transportation Research Interdisciplinary Perspectives
Figliozzi and Unnikrishnan (2021a)	Exploring the impact of socio-demographic characteristics, health concerns, and product type on home delivery rates and expenditures during a strict COVID-19 lockdown period: A case study from Portland, OR	Transportation Research Part A-Policy and Practice
Kapser et al. (2021)	Autonomous delivery vehicles to fight the spread of Covid-19-How do men and women differ in their acceptance?	Transportation Research Part A-Policy and Practice
Wang et al. (2021d)	Adoption of delivery services in light of the COVID pandemic: Who and how long?	Transportation Research Part A-Policy and Practice
Figliozzi and Unnikrishnan (2021b)	Home-deliveries before-during COVID-19 lockdown: Accessibility, environmental justice, equity, and policy implications	Transportation Research Part D-Transport and Environment
Pani et al. (2020)	Evaluating public acceptance of autonomous delivery robots during COVID-19 pandemic	Transportation Research Part D-Transport and Environment
Burgos and Ivanov (2021)	Food retail supply chain resilience and the COVID-19 pandemic: A digital twin-based impact analysis and improvement directions	Transportation Research Part E-Logistics and Transportation Review
Choi (2020)	Innovative "Bring-Service-Near-Your-Home" operations under Corona-Virus (COVID-19/SARS-CoV-2) outbreak: Can logistics become the Messiah?	Transportation Research Part E-Logistics and Transportation Review
Choi (2021b)	Risk analysis in logistics systems: A research agenda during and after the COVID-19 pandemic	Transportation Research Part E-Logistics and Transportation Review
Chowdhury et al. (2021)	COVID-19 pandemic related supply chain studies: A systematic review	Transportation Research Part E-Logistics and Transportation Review
Govindan et al. (2020)	A decision support system for demand management in healthcare supply chains considering the epidemic outbreaks: A case study of coronavirus disease 2019 (COVID-19)	Transportation Research Part E-Logistics and Transportation Review
Ivanov (2020)	Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case	Transportation Research Part E-Logistics and Transportation Review
Lin et al. (2021)	The effects of supply chain diversification during the COVID-19 crisis: Evidence from Chinese manufacturers	Transportation Research Part E-Logistics and Transportation Review
Liu et al. (2021a)	Medical supplies scheduling in major public health emergencies	Transportation Research Part E-Logistics and Transportation Review
Mitrega and Choi (2021)	How small-and-medium transportation companies handle asymmetric customer relationships under COVID-19 pandemic: A multi-method study	Transportation Research Part E-Logistics and Transportation Review
Yazdekhasti et al. (2021)	A multi-period multi-modal stochastic supply chain model under COVID pandemic: A poultry industry case study in Mississippi	Transportation Research Part E-Logistics and Transportation Review
Mode choice		
Harrington and Hadjiconstantinou (2021)	Changes in commuting behaviours in response to the COVID-19 pandemic in the UK	Journal of Transport & Health
Lee et al. (2021a)	Impacts of COVID-19 on individuals’ mobility behavior in Pakistan based on self-reported responses	Journal of Transport & Health
Aaditya and Rahul (2021b)	Psychological impacts of COVID-19 pandemic on the mode choice behaviour: A hybrid choice modelling approach	Transport Policy

Author(s) (year)	Title	Journal
Das et al. (2021)	Impact of COVID-19: A radical modal shift from public to private transport mode	Transport Policy
Eisenmann et al. (2021)	Transport mode use during the COVID-19 lockdown period in Germany: The car became more important, public transport lost ground	Transport Policy
Loa et al. (2021b)	Exploring the impacts of the COVID-19 pandemic on modality profiles for non-mandatory trips in the Greater Toronto Area	Transport Policy
Luan et al. (2021)	Exploring the impact of COVID-19 on individual's travel mode choice in China	Transport Policy
Shaer and Haghshenas (2021a)	Evaluating the effects of the COVID-19 outbreak on the older adults' travel mode choices	Transport Policy
Bari et al. (2021)	Impact of COVID-19 on educational trips - an Indian case study	Transportation Letters
Abdullah et al. (2020)	Exploring the impacts of COVID-19 on travel behavior and mode preferences	Transportation Research Interdisciplinary Perspectives
Bhaduri et al. (2020)	Modelling the effects of COVID-19 on travel mode choice behaviour in India	Transportation Research Interdisciplinary Perspectives
Bucsky (2020)	Modal share changes due to COVID-19: The case of Budapest	Transportation Research Interdisciplinary Perspectives
Hadjidemetriou et al. (2020)	The impact of government measures and human mobility trend on COVID-19 related deaths in the UK	Transportation Research Interdisciplinary Perspectives
La Paix (2021)	Impact of COVID-19 restrictions on mode use and mode captivity the city of Santo Domingo in Latin America	Transportation Research Interdisciplinary Perspectives
La Paix (2021)	Impact of COVID-19 restrictions on mode use and mode captivity the city of Santo Domingo in Latin America	Transportation Research Interdisciplinary Perspectives
Schmidt et al. (2021)	COVID-19 – A window of opportunity for the transition toward sustainable mobility?	Transportation Research Interdisciplinary Perspectives
Simons et al. (2021)	Covid-19 and its effect on trip mode and destination decisions of transit riders: Experience from Ohio	Transportation Research Interdisciplinary Perspectives
Hensher et al. (2022a)	The impact of working from home on modal commuting choice response during COVID-19: Implications for two metropolitan areas in Australia	Transportation Research Part A: Policy and Practice
Schaefer et al. (2021)	Transport disrupted – Substituting public transport by bike or car under Covid 19	Transportation Research Part A: Policy and Practice
Ciuffini et al. (2021)	Mitigating Increased Driving after the COVID-19 Pandemic: An Analysis on Mode Share, Travel Demand, and Public Transport Capacity	Transportation Research Record
Public transport operations & ridership		
Mutlu et al. (2021)	COVID-19 transmission risk minimization at public transportation stops using Differential Evolution algorithm	European Journal of Transport and Infrastructure Research
Almlof et al. (2021)	Who continued travelling by public transport during COVID-19? Socioeconomic factors explaining travel behaviour in Stockholm 2020 based on smart card data	European Transport Research Review
Tirachini and Cats (2020)	COVID-19 and Public Transportation: Current Assessment, Prospects, and Research Needs	Journal of Public Transportation
Guellich et al. (2021)	The face mask-touching behavior during the COVID-19 pandemic: Observational study of public transportation users in the greater Paris region: The French-mask-touch study	Journal of Transport & Health
Nguyen and Pojani (2021)	Covid-19 need not spell the death of public transport: Learning from Hanoi's safety measures	Journal of Transport & Health
Palm et al. (2021)	The uneven impacts of avoiding public transit on riders' access to healthcare during COVID-19	Journal of Transport & Health
Ross (2021)	Public transport and public health: Regulatory focus and the impact of COVID-19 on the choice of public transport mode	Journal of Transport & Health
Chang et al. (2021)	Does COVID-19 affect metro use in Taipei?	Journal of Transport Geography
Basu and Ferreira (2021)	Sustainable mobility in auto-dominated Metro Boston: Challenges and opportunities post-COVID-19	Transport Policy
Dai et al. (2021)	Improving the subway attraction for the post-COVID-19 era: The role of fare-free public transport policy	Transport Policy
Elias and Zatmeh-Kanj (2021)	Extent to which COVID-19 will affect future use of the train in Israel	Transport Policy
Hirschhorn (2021)	A multi-level governance response to the Covid-19 crisis in public transport	Transport Policy
Kamga and Eickemeyer (2021)	Slowing the spread of COVID-19: Review of "Social distancing" interventions deployed by public transit in the United States and Canada	Transport Policy
Parashar and Cheriyan (2021)	Application of mobility related data during pandemic: opportunities, issues and challenges in India	Transport Policy
Parker et al. (2021)	Public transit use in the United States in the era of COVID-19: Transit riders' travel behavior in the COVID-19 impact and recovery period	Transport Policy
Sameni et al. (2021)	Will modal shift occur from subway to other modes of transportation in the post-corona world in developing countries?	Transport Policy
Vickerman (2021)	Will Covid-19 put the public back in public transport? A UK perspective	Transport Policy
Xin et al. (2021)	Impacts of COVID-19 on urban rail transit ridership using the Synthetic Control Method	Transport Policy

Author(s) (year)	Title	Journal
Gkiotsalitis and Cats (2021b)	Public transport planning adaption under the COVID-19 pandemic crisis: literature review of research needs and directions	Transport Reviews
Horcher et al. (2021)	Social distancing in public transport: mobilising new technologies for demand management under the Covid-19 crisis	Transportation
Cho and Park (2021)	Exploring the Behaviour Change of Crowding Impedance on Public Transit due to COVID-19 Pandemic: Before and After Comparison	Transportation Letters
Ashraf Javid et al. (2021)	Structural equation modeling of public transport use with COVID-19 precautions: An extension of the norm activation model	Transportation Research Interdisciplinary Perspectives
Diaz et al. (2021)	Canadian transit agencies response to COVID-19: Understanding strategies, information accessibility and the use of social media	Transportation Research Interdisciplinary Perspectives
Diaz et al. (2021)	Canadian transit agencies response to COVID-19: Understanding strategies, information accessibility and the use of social media	Transportation Research Interdisciplinary Perspectives
Dzisi and Dei (2020)	Adherence to social distancing and wearing of masks within public transportation during the COVID 19 pandemic	Transportation Research Interdisciplinary Perspectives
Gkiotsalitis (2021)	A model for modifying the public transport service patterns to account for the imposed COVID-19 capacity	Transportation Research Interdisciplinary Perspectives
Jenelius and Cebecauer (2020)	Impacts of COVID-19 on public transport ridership in Sweden: Analysis of ticket validations, sales and passenger counts	Transportation Research Interdisciplinary Perspectives
Maji et al. (2020)	Implication of repatriating migrant workers on COVID-19 spread and transportation requirements	Transportation Research Interdisciplinary Perspectives
Rasca et al. (2021)	Impacts of COVID-19 and pandemic control measures on public transport ridership in European urban areas – The cases of Vienna, Innsbruck, Oslo, and Agder	Transportation Research Interdisciplinary Perspectives
Simons et al. (2021)	Covid-19 and its effect on trip mode and destination decisions of transit riders: Experience from Ohio	Transportation Research Interdisciplinary Perspectives
Tiikkaja and Viri (2021)	The effects of COVID-19 epidemic on public transport ridership and frequencies. A case study from Tampere, Finland	Transportation Research Interdisciplinary Perspectives
Auad et al. (2021)	Resiliency of on-demand multimodal transit systems during a pandemic	Transportation Research Part C-Emerging Technologies
Mo et al. (2021)	Modeling epidemic spreading through public transit using time-varying encounter network	Transportation Research Part C-Emerging Technologies
Hu and Chen (2021)	Who left riding transit? Examining socioeconomic disparities in the impact of COVID-19 on ridership	Transportation Research Part D-Transport and Environment
Halvorsen et al. (2021)	Examination of New York City Transit's Bus and Subway Ridership Trends During the COVID-19 Pandemic	Transportation Research Record
Jayatilake and Bunker (2021)	Impact of COVID-19 on Waiting Passenger Distribution on a Bus Rapid Transit Station Platform in Brisbane, Australia	Transportation Research Record
Tardivo et al. (2021)	COVID-19 Impact on Transport: A Paper from the Railways' Systems Research Perspective	Transportation Research Record
Gkiotsalitis and Cats (2021a)	Optimal frequency setting of metro services in the age of COVID-19 distancing measures	Transportmetrica a-Transport Science
Ridesharing, bikeshare services and taxis (shared mobility)		
Awad-Nunez et al. (2021a)	Post-COVID-19 travel behaviour patterns: impact on the willingness to pay of users of public transport and shared mobility services in Spain	European Transport Research Review
Hua et al. (2021)	Should bike-sharing continue operating during the COVID-19 pandemic? Empirical findings from Nanjing, China	Journal of Transport & Health
Hu et al. (2021a)	Examining spatiotemporal changing patterns of bike-sharing usage during COVID-19 pandemic	Journal of Transport Geography
Meredith-Karam et al. (2021)	The relationship between ridehailing and public transit in Chicago: A comparison before and after COVID-19	Journal of Transport Geography
Bergantino et al. (2021)	Influencing factors for potential bike-sharing users: an empirical analysis during the COVID-19 pandemic	Research in Transportation Economics
Lei and Ozbay (2021)	A robust analysis of the impacts of the stay-at-home policy on taxi and Citi Bike usage: A case study of Manhattan	Transport Policy
Naveen and Gurtoo (2022)	Public transport strategy and epidemic prevention framework in the Context of Covid-19	Transport Policy
Wang and Noland (2021)	Bikeshare and subway ridership changes during the COVID-19 pandemic in New York City	Transport Policy
Hensher (2020)	What might Covid-19 mean for mobility as a service (MaaS)?	Transport Reviews
Loa et al. (2021a)	How have ride-sourcing users adapted to the first wave of the COVID-19 pandemic? evidence from a survey-based study of the Greater Toronto Area	Transportation Letters
Borowski et al. (2021)	Dueling emergencies: Flood evacuation ridesharing during the COVID-19 pandemic	Transportation Research Interdisciplinary Perspectives
Jobe and Griffin (2021)	Bike share responses to COVID-19	Transportation Research Interdisciplinary Perspectives

Author(s) (year)	Title	Journal
Padmanabhan et al. (2021)	COVID-19 effects on shared-biking in New York, Boston, and Chicago	Transportation Research Interdisciplinary Perspectives
Teixeira and Lopes (2020)	The link between bike sharing and subway use during the COVID-19 pandemic: The case-study of New York's Citi Bike	Transportation Research Interdisciplinary Perspectives
Li et al. (2021a)	Impacts of COVID-19 on the usage of public bicycle share in London	Transportation Research Part A-Policy and Practice
Zheng et al. (2021)	Plunge and rebound of a taxi market through COVID-19 lockdown: Lessons learned from Shenzhen, China	Transportation Research Part A-Policy and Practice
Loa et al. (2022)	How has the COVID-19 pandemic affected the use of ride-sourcing services? An empirical evidence-based investigation for the Greater Toronto Area	Transportation Research Part A-Policy and Practice
Wang et al. (2022)	The impact of COVID-19 on the ride-sharing industry and its recovery: Causal evidence from China	Transportation Research Part A-Policy and Practice
Rahimi et al. (2021)	Perceived risk of using shared mobility services during the COVID-19 pandemic	Transportation Research Part F-Traffic Psychology and Behaviour
Teixeira et al. (2021)	The motivations for using bike sharing during the COVID-19 pandemic: Insights from Lisbon	Transportation Research Part F-Traffic Psychology and Behaviour
Brown and Williams (2021)	Equity Implications of Ride-Hail Travel during COVID-19 in California	Transportation Research Record
Road safety & traffic crashes		
Adanu et al. (2021)	How did the COVID-19 pandemic affect road crashes and crash outcomes in Alabama?	Accident Analysis and Prevention
Doucette et al. (2021)	Evaluation of motor vehicle crash rates during and after the COVID-19-associated stay-at-home order in Connecticut	Accident Analysis and Prevention
Feiss et al. (2021)	Balancing safety on the road with risk from COVID-19: A content analysis of policy adaptations by Divisions of Motor Vehicles	Accident Analysis and Prevention
Qureshi et al. (2020)	Mandated societal lockdown and road traffic accidents	Accident Analysis and Prevention
Rapoport et al. (2021)	Impact of COVID-19 on motor vehicle injuries and fatalities in older adults in Ontario, Canada	Accident Analysis and Prevention
Sekadakis et al. (2021)	Analysis of the impact of COVID-19 on collisions, fatalities and injuries using time series forecasting: The case of Greece	Accident Analysis and Prevention
Stavrinos et al. (2020)	Adolescent driving behavior before and during restrictions related to COVID-19	Accident Analysis and Prevention
Tucker and Marsh (2021)	Speeding through the pandemic: Perceptual and psychological factors associated with speeding during the COVID-19 stay-at-home period	Accident Analysis and Prevention
Vanlaar et al. (2021)	The impact of COVID-19 on road safety in Canada and the United States	Accident Analysis and Prevention
Vinglis et al. (2020)	Coronavirus disease 2019: What could be the effects on Road safety?	Accident Analysis and Prevention
Katrakazas et al. (2021)	Identifying the impact of the COVID-19 pandemic on driving behavior using naturalistic driving data and time series forecasting	Journal of Safety Research
Abootalebi et al. (2021)	Facing double jeopardy: Experiences of driving cessation in older adults during COVID-19 pandemic	Journal of Transport & Health
Davis and Obree (2020)	Equality of restraint: Reframing road safety through the ethics of private motorised transport	Journal of Transport & Health
Ishmam et al. (2021)	A joint analysis of roadway accident frequency and injury severity to investigate the effects of covid-19 in bangladesh: application of artificial neural network and structural equation models	Journal of Transport & Health
Monfort et al. (2021)	Weekday bicycle traffic and crash rates during the COVID-19 pandemic	Journal of Transport & Health
Beccegato et al. (2021)	Coronavirus lockdown: Excessive alcohol consumption and illicit substance use in DUI subjects	Traffic Injury Prevention
Rudisill (2021)	The association between a statewide stay-at-home order and motor vehicle injury rates among population sub-groups in West Virginia	Traffic Injury Prevention
Truelove et al. (2021)	Driving through a pandemic: A study of speeding and phone use while driving during COVID-19 restrictions	Traffic Injury Prevention
Colonna and Intini (2020)	Compensation effect between deaths from Covid-19 and crashes: The Italian case	Transportation Research Interdisciplinary Perspectives
Katrakazas et al. (2020)	A descriptive analysis of the effect of the COVID-19 pandemic on driving behavior and road safety	Transportation Research Interdisciplinary Perspectives
Saladié et al. (2020)	COVID-19 lockdown and reduction of traffic accidents in Tarragona province, Spain	Transportation Research Interdisciplinary Perspectives
Vanlaar et al. (2021)	Drink driving during the COVID-19 pandemic	Transportation Research Part F-Traffic Psychology and Behaviour
Stiles et al. (2021)	Lower Volumes, Higher Speeds: Changes to Crash Type, Timing, and Severity on Urban Roads from COVID-19 Stay-at-Home Policies	Transportation Research Record
Travel behaviour & mobility changes		

Author(s) (year)	Title	Journal
Ecke et al. (2021)	Tracing the effects of the Covid-19 pandemic on car usage in Germany - an analysis of the German Mobility Panel	European Journal of Transport and Infrastructure Research
Shibayama et al. (2021)	Impact of COVID-19 lockdown on commuting: a multi-country perspective	European Journal of Transport and Infrastructure Research
Anke et al. (2021)	Impact of SARS-CoV-2 on the mobility behaviour in Germany	European Transport Research Review
Bin et al. (2021)	The trade-off behaviours between virtual and physical activities during the first wave of the COVID-19 pandemic period	European Transport Research Review
Kolarova et al. (2021)	Analysing the impact of the COVID-19 outbreak on everyday travel behaviour in Germany and potential implications for future travel patterns	European Transport Research Review
Konig and Dressler (2021)	A mixed-methods analysis of mobility behavior changes in the COVID-19 era in a rural case study	European Transport Research Review
Politis et al. (2021a)	Mapping travel behavior changes during the COVID-19 lock-down: a socioeconomic analysis in Greece	European Transport Research Review
Gargoum and Gargoum (2021)	Limiting mobility during COVID-19, when and to what level? An international comparative study using change point analysis	Journal of Transport & Health
Gonzalez-Marin and Garrido-Cumbrera (2021)	Changes in mobility patterns for accessing urban green spaces during the covid-19 pandemic: a rapid scoping review	Journal of Transport & Health
Iqra et al. (2021)	Factors affecting mobility patterns during official lockdown period in bangladesh: a case of covid-19	Journal of Transport & Health
Lee et al. (2021b)	Impacts of COVID-19 on individuals' mobility behavior in Pakistan based on self-reported responses	Journal of Transport & Health
Linares-Rendon and Garrido-Cumbrera (2021)	Impact of the covid-19 pandemic on urban mobility: a systematic review of the existing literature	Journal of Transport & Health
Noland (2021)	Mobility and the effective reproduction rate of COVID-19	Journal of Transport & Health
Tokey (2021)	Spatial association of mobility and COVID-19 infection rate in the USA: A county-level study using mobile phone location data	Journal of Transport & Health
Borkowski et al. (2021)	Lockdowned: Everyday mobility changes in response to COVID-19	Journal of Transport Geography
Kim and Kwan (2021)	The impact of the COVID-19 pandemic on people's mobility: A longitudinal study of the US from March to September of 2020	Journal of Transport Geography
Li et al. (2021e)	Exploring the dynamic impacts of COVID-19 on intercity travel in China	Journal of Transport Geography
Liu et al. (2021c)	Elderly mobility during the COVID-19 pandemic: A qualitative exploration in Kunming, China	Journal of Transport Geography
van Wee and Witlox (2021)	COVID-19 and its long-term effects on activity participation and travel behaviour: A multiperspective view	Journal of Transport Geography
Zhou et al. (2021c)	Unravel the impact of COVID-19 on the spatio-temporal mobility patterns of microtransit	Journal of Transport Geography
Cresswell (2021)	Valuing mobility in a post COVID-19 world	Mobilities
Freudendal-Pedersen and Kesselring (2021)	What is the urban without physical mobilities? COVID-19-induced immobility in the mobile risk society	Mobilities
Salazar (2021)	Existential vs. essential mobilities: insights from before, during and after a crisis	Mobilities
Abdullah et al. (2021)	Measuring changes in travel behavior pattern due to COVID-19 in a developing country: A case study of Pakistan	Transport Policy
Beck and Hensher (2020a)	Insights into the impact of COVID-19 on household travel and activities in Australia - The early days of easing restrictions	Transport Policy
Beck and Hensher (2020b)	Insights into the impact of COVID-19 on household travel and activities in Australia - The early days under restrictions	Transport Policy
Bohman et al. (2021)	A study of changes in everyday mobility during the Covid-19 pandemic: As perceived by people living in Malmo, Sweden	Transport Policy
Chan et al. (2021)	COVID-19, community response, public policy, and travel patterns: A tale of Hong Kong	Transport Policy
da Silva et al. (2021)	Comparing community mobility reduction between first and second COVID-19 waves	Transport Policy
Delbosc and McCarthy (2021)	Pushed back, pulled forward: Exploring the impact of COVID-19 on young adults' life plans and future mobility	Transport Policy
Ding and Zhang (2021)	Dynamic associations between temporal behavior changes caused by the COVID-19 pandemic and subjective assessments of policymaking: A case study in Japan	Transport Policy
Echaniz et al. (2021)	Behavioural changes in transport and future repercussions of the COVID-19 outbreak in Spain	Transport Policy
Molloy et al. (2021)	Observed impacts of the Covid-19 first wave on travel behaviour in Switzerland based on a large GPS panel	Transport Policy
Porter et al. (2021)	Women's mobility and transport in the peripheries of three African cities: Reflecting on early impacts of COVID-19	Transport Policy
Thombre and Agarwal (2021)	A paradigm shift in urban mobility: Policy insights from travel before and after COVID-19 to seize the opportunity	Transport Policy
Wang et al. (2021c)	COVid-19 influenced households' Interrupted Travel Schedules (COVHITS) survey: Lessons from the fall 2020 cycle	Transport Policy
Shortall et al. (2021)	COVID-19 passenger transport measures and their impacts	Transport Reviews
Irawan et al. (2021)	Exploring activity-travel behavior changes during the beginning of COVID-19 pandemic in Indonesia	Transportation
Najmi et al. (2021)	Easing or tightening control strategies: determination of COVID-19 parameters for an agent-based model	Transportation

Author(s) (year)	Title	Journal
Aaditya and Rahul (2021a)	A comprehensive analysis of the trip frequency behavior in COVID scenario	Transportation Letters
Dingil and Esztergar-Kiss (2021)	The Influence of the Covid-19 Pandemic on Mobility Patterns: The First Wave's Results	Transportation Letters
Gupta et al. (2021)	Impact of lockdown and change in mobility patterns on road fatalities during COVID-19 pandemic	Transportation Letters
Habib et al. (2021)	Assessing the impacts of COVID-19 on urban passenger travel demand in the greater Toronto area: description of a multi-pronged and multi-staged study with initial results	Transportation Letters
Jiao and Azimian (2021)	Exploring the factors affecting travel behaviors during the second phase of the COVID-19 pandemic in the United States	Transportation Letters
Jiao et al. (2021)	Measuring travel behavior in Houston, Texas with mobility data during the 2020 COVID-19 outbreak	Transportation Letters
Kamplimath et al. (2021)	A user opinion survey on the probable impact of COVID-19 on long-distance travel in India	Transportation Letters
Kopsidas et al. (2021)	How did the COVID-19 pandemic impact traveler behavior toward public transport? The case of Athens, Greece	Transportation Letters
Arimura et al. (2020)	Changes in urban mobility in Sapporo city, Japan due to the Covid-19 emergency declarations	Transportation Research Interdisciplinary Perspectives
de Haas et al. (2020)	How COVID-19 and the Dutch 'intelligent lockdown' change activities, work and travel behaviour: Evidence from longitudinal data in the Netherlands	Transportation Research Interdisciplinary Perspectives
De Vos (2020)	The effect of COVID-19 and subsequent social distancing on travel behavior	Transportation Research Interdisciplinary Perspectives
Fatmi et al. (2021)	COVID-19 and Travel: How Our Out-of-home Travel Activity, In-home Activity, and Long-Distance Travel Have Changed	Transportation Research Interdisciplinary Perspectives
Hara and Yamaguchi (2021)	Japanese travel behavior trends and change under COVID-19 state-of-emergency declaration: Nationwide observation by mobile phone location data	Transportation Research Interdisciplinary Perspectives
Iio et al. (2021)	COVID-19 and social distancing: Disparities in mobility adaptation between income groups	Transportation Research Interdisciplinary Perspectives
Kartal et al. (2021)	The relationship between mobility and COVID-19 pandemic: Daily evidence from an emerging country by causality analysis	Transportation Research Interdisciplinary Perspectives
Mayo et al. (2021)	Exploring the changes in travel behavior in a developing country amidst the COVID-19 pandemic: Insights from Metro Cebu, Philippines	Transportation Research Interdisciplinary Perspectives
Politis et al. (2021b)	COVID-19 lockdown measures and travel behavior: The case of Thessaloniki, Greece	Transportation Research Interdisciplinary Perspectives
Shamshiripour et al. (2020)	How is COVID-19 reshaping activity-travel behavior? Evidence from a comprehensive survey in Chicago	Transportation Research Interdisciplinary Perspectives
Truong and Truong (2021)	Projecting daily travel behavior by distance during the pandemic and the spread of COVID-19 infections – Are we in a closed loop scenario?	Transportation Research Interdisciplinary Perspectives
Yang et al. (2021b)	Exploring the relationship between the COVID-19 pandemic and changes in travel behaviour: A qualitative study	Transportation Research Interdisciplinary Perspectives
Yang et al. (2021b)	Exploring the relationship between the COVID-19 pandemic and changes in travel behaviour: A qualitative study	Transportation Research Interdisciplinary Perspectives
Bian et al. (2021b)	Time lag effects of COVID-19 policies on transportation systems: A comparative study of New York City and Seattle	Transportation Research Part A: Policy and Practice
Currie et al. (2021)	Evidence of a post-COVID change in travel behaviour – Self-reported expectations of commuting in Melbourne	Transportation Research Part A: Policy and Practice
Park et al. (2022)	A double jeopardy: COVID-19 impacts on the travel behavior and community living of people with disabilities	Transportation Research Part A: Policy and Practice
Hu et al. (2021b)	A big-data driven approach to analyzing and modeling human mobility trend under non-pharmaceutical interventions during COVID-19 pandemic	Transportation Research Part C-Emerging Technologies
Liu et al. (2021d)	Dynamic activity chain pattern estimation under mobility demand changes during COVID-19	Transportation Research Part C-Emerging Technologies
Vo et al. (2021)	A mixed-equilibrium model of individual and household activity-travel choices in multimodal transportation networks	Transportation Research Part C-Emerging Technologies
Habib and Anik (2021)	Impacts of COVID-19 on Transport Modes and Mobility Behavior: Analysis of Public Discourse in Twitter	Transportation Research Record
Ye et al. (2021)	Impact of Social Media on Travel Behaviors during the COVID-19 Pandemic: Evidence from New York City	Transportation Research Record
Guzman et al. (2021)	COVID-19, activity and mobility patterns in Bogota. Are we ready for a '15-minute city'?	Travel Behaviour and Society
Pawar et al. (2021)	Modelling work- and non-work-based trip patterns during transition to lockdown period of COVID-19 pandemic in India	Travel Behaviour and Society
Congestion, emission & sustainability effects		

Author(s) (year)	Title	Journal
Mahajan et al. (2021)	Explaining demand patterns during COVID-19 using opportunistic data: a case study of the city of Munich	European Transport Research Review
Simunek et al. (2021)	The Impact of the COVID-19 Movement Restrictions on the Road Traffic in the Czech Republic during the State of Emergency	Journal of Advanced Transportation
Albayati et al. (2021)	Effect of COVID-19 on air quality and pollution in different countries	Journal of Transport & Health
Polednik (2021)	COVID-19 lockdown and particle exposure of road users	Journal of Transport & Health
Rahman et al. (2021)	Transformation of urban mobility during COVID-19 pandemic – Lessons for transportation planning	Journal of Transport & Health
Crowley et al. (2021)	The impact of labour market disruptions and transport choice on the environment during COVID-19	Transport Policy
Hensher et al. (2021c)	The impact of COVID-19 on cost outlays for car and public transport commuting-The case of the Greater Sydney Metropolitan Area after three months of restrictions	Transport Policy
Muley et al. (2021)	Quantifying the impact of COVID? 19 preventive measures on traffic in the State of Qatar	Transport Policy
Rothengatter et al. (2021)	Pandemic waves and the time after Covid-19-Consequences for the transport sector	Transport Policy
Patra et al. (2021)	Analysis of road traffic pattern changes due to activity restrictions during COVID-19 pandemic in Chennai	Transportation Letters
Budd and Ison (2020)	Responsible Transport: A post-COVID agenda for transport policy and practice	Transportation Research Interdisciplinary Perspectives
Wang et al. (2021a)	Mobility in post-pandemic economic reopening under social distancing guidelines: Congestion, emissions, and contact exposure in public transit	Transportation Research Part A-Policy and Practice
Fisher and LaMondia (2021)	Understanding the Temporal, Regional, Demographic, and Policy Factors Influencing Counties' Daily Traffic Volume Reductions in Response to COVID-19	Transportation Research Record
Economic impacts		
An et al. (2021)	Dynamic governance decisions on multi-modal inter-city travel during a large-scale epidemic spreading	Transport Policy
Junior et al. (2021)	COVID-19, public agglomerations and economic effects: Assessing the recovery time of passenger transport services in Brazil	Transport Policy
Oum and Wang (2020)	Socially optimal lockdown and travel restrictions for fighting communicable virus including COVID-19	Transport Policy
Zhang and Tong (2021)	The economic impacts of traffic consumption during the COVID-19 pandemic in China: A CGE analysis	Transport Policy
Mack et al. (2021)	The impacts of the COVID-19 pandemic on transportation employment: A comparative analysis	Transportation Research Interdisciplinary Perspectives
Wild (2021)	Corporate social responsibility, cost structures, and COVID-19: Impact of passenger behavior on business models	Transportation Research Interdisciplinary Perspectives
Hensher et al. (2021a)	What does the quantum of working from home do to the value of commuting time used in transport appraisal?	Transportation Research Part A-Policy and Practice
Ding et al. (2021)	TLQP: Early-stage transportation lock-down and quarantine problem	Transportation Research Part C-Emerging Technologies
Mouratidis et al. (2021)	Transportation technologies, sharing economy, and teleactivities: Implications for built environment and travel	Transportation Research Part D-Transport and Environment
Cherry et al. (2021)	Quantifying the Impact of the COVID-19 Pandemic on Passenger Vehicle Drivers' Willingness to Pay for Travel Time Savings and Reliability	Transportation Research Record
Hamilton and Maliphol (2021)	Reimagining China's Transportation Funding Investments in Africa in the Context of COVID-19	Transportation Research Record
Active transport & sustainable transport		
Cusack (2021)	Individual, social, and environmental factors associated with active transportation commuting during the COVID-19 pandemic	Journal of Transport & Health
Kazemzadeh and Koglin (2021)	Electric bike (non)users? health and comfort concerns pre and peri a world pandemic (COVID-19): A qualitative study	Journal of Transport & Health
Musselwhite et al. (2020)	Editorial JTH 16-The Coronavirus Disease COVID-19 and implications for transport and health	Journal of Transport & Health
Schneider et al. (2021)	An integrated approach to monitoring and estimating COVID-19 risk exposure among leisure-time physical activity participants	Journal of Transport & Health
Semple et al. (2021)	Trips for outdoor exercise at different stages of the COVID-19 pandemic in Scotland	Journal of Transport & Health
Shaer and Haghshenas (2021b)	The impacts of COVID-19 on older adults' active transportation mode usage in Isfahan, Iran	Journal of Transport & Health
Nguyen et al. (2021)	The impact of Covid-19 on children's active travel to school in Vietnam	Journal of Transport Geography
Scorrano and Danielis (2021)	Active mobility in an Italian city: Mode choice determinants and attitudes before and during the Covid-19 emergency	Research in Transportation Economics
Awad-Nunez et al. (2021b)	Acceptability of sustainable mobility policies under a post-COVID-19 scenario. Evidence from Spain	Transport Policy
Carrese et al. (2021)	Analysis and monitoring of post-COVID mobility demand in Rome resulting from the adoption of sustainable mobility measures	Transport Policy

Author(s) (year)	Title	Journal
Zhang and Fricker (2021)	Quantifying the impact of COVID-19 on non-motorized transportation: A Bayesian structural time series model	Transport Policy
Zhang et al. (2020b)	Exploring the roles of high-speed train, air and coach services in the spread of COVID-19 in China	Transport Policy
Buehler and Pucher (2021)	COVID-19 Impacts on Cycling, 2019-2020	Transport Reviews
Fuller et al. (2021)	The reactivated bike: Self-reported cycling activity during the 2020 COVID-19 pandemic in Australia	Transportation Research Interdisciplinary Perspectives
Pedestrians, foot traffic & passengers		
Coppola and De Fabiis (2021)	Impacts of interpersonal distancing on-board trains during the COVID-19 emergency	European Transport Research Review
Wu et al. (2021)	Computational modeling of on-flight covid-19 spread incorporating pedestrian movement	Journal of Transport & Health
Zuo et al. (2021)	Reference-free video-to-real distance approximation-based urban social distancing analytics amid COVID-19 pandemic	Journal of Transport & Health
Xiao et al. (2021)	Modeling indoor-level non-pharmaceutical interventions during the COVID-19 pandemic: A pedestrian dynamics-based microscopic simulation approach	Transport Policy
Romero et al. (2020)	COVID-19 indoor exposure levels: An analysis of foot traffic scenarios within an academic building	Transportation Research Interdisciplinary Perspectives
Aghabayk et al. (2021)	Effects of COVID-19 on rail passengers' crowding perceptions	Transportation Research Part A: Policy and Practice
Singleton et al. (2021)	Impact of COVID-19 on Traffic Signal Systems: Survey of Agency Interventions and Observed Changes in Pedestrian Activity	Transportation Research Record
Li and Yin (2021)	A pedestrian-based model for simulating COVID-19 transmission on college campus	Transportmetrica a-Transport Science
Telework & mental health		
Hiselius and Arnfalk (2021)	When the impossible becomes possible: COVID-19's impact on work and travel patterns in Swedish public agencies	European Transport Research Review
Dam et al. (2020)	COVID-19: Impact on transport and mental health	Journal of Transport & Health
Waygood et al. (2021)	Do you miss your friends? life satisfaction during the second wave of covid-19	Journal of Transport & Health
Balbontin et al. (2021)	Impact of COVID-19 on the number of days working from home and commuting travel: A cross-cultural comparison between Australia, South America and South Africa	Journal of Transport Geography
Beck et al. (2020)	Slowly coming out of COVID-19 restrictions in Australia: Implications for working from home and commuting trips by car and public transport	Journal of Transport Geography
Nayak and Pandit (2021)	Potential of telecommuting for different employees in the Indian context beyond COVID-19 lockdown	Transport Policy
Nguyen (2021)	Factors influencing home-based telework in Hanoi (Vietnam) during and after the COVID-19 era	Transportation
Barbour et al. (2021)	A statistical assessment of work-from-home participation during different stages of the COVID-19 pandemic	Transportation Research Interdisciplinary Perspectives
Olde Kalter et al. (2021)	Post COVID-19 teleworking and car use intentions. Evidence from large scale GPS-tracking and survey data in the Netherlands	Transportation Research Interdisciplinary Perspectives
Olde Kalter et al. (2021)	Post COVID-19 teleworking and car use intentions. Evidence from large scale GPS-tracking and survey data in the Netherlands	Transportation Research Interdisciplinary Perspectives
Tsouros et al. (2021)	Activities, time-use and mental health during the first COVID-19 pandemic wave: Insight from Greece	Transportation Research Interdisciplinary Perspectives
Yabe et al. (2021)	Relationship between Internet use and out-of-home activities during the first wave of the COVID-19 outbreak in Japan	Transportation Research Interdisciplinary Perspectives
Hensher et al. (2021b)	Working from home and its implications for strategic transport modelling based on the early days of the COVID-19 pandemic	Transportation Research Part A: Policy and Practice
Jain et al. (2021)	COVID and Working from Home: Long-term Impacts and Psycho-social Daterminants	Transportation Research Part A: Policy and Practice
Kroesen (2022)	Working from home during the corona-crisis is associated with higher subjective well-being for women with long (pre-corona) commutes	Transportation Research Part A: Policy and Practice
Tahlyan et al. (2022)	For whom did telework not work during the Pandemic? understanding the factors impacting telework satisfaction in the US using a multiple indicator multiple cause (MIMIC) model	Transportation Research Part A: Policy and Practice
Travel risk perception		
James et al. (2021)	COVID-19 related risk perception among taxi operators in Kingston and St. Andrew, Jamaica	Journal of Transport & Health
Beck et al. (2021)	Public transport trends in Australia during the COVID-19 pandemic: An investigation of the influence of bio-security concerns on trip behaviour	Journal of Transport Geography
Zuev and Hannam (2021)	Anxious immobilities: an ethnography of coping with contagion (Covid-19) in Macau	Mobilities
Hotle et al. (2020)	Influenza risk perception and travel-related health protection behavior in the US: Insights for the aftermath of the COVID-19 outbreak	Transportation Research Interdisciplinary Perspectives

Author(s) (year)	Title	Journal
Ozbilen et al. (2021)	Perceived risk of infection while traveling during the COVID-19 pandemic: Insights from Columbus, OH	Transportation Research Interdisciplinary Perspectives
Parady et al. (2020)	Travel behavior changes during the COVID-19 pandemic in Japan: Analyzing the effects of risk perception and social influence on going-out self-restriction	Transportation Research Interdisciplinary Perspectives
Thomas et al. (2021)	Commuting before and after COVID-19	Transportation Research Interdisciplinary Perspectives
Zavareh et al. (2021)	Demand for mitigating the risk of COVID-19 infection in public transport: the role of social trust and fatalistic beliefs	Transportation Research Part F: Traffic Psychology and Behaviour
Travel satisfaction, access & equity		
Bledsoe et al. (2021)	Special Report from the CDC: Strengthening social connections to prevent suicide and adverse childhood experiences (ACEs): Actions and opportunities during the COVID-19 pandemic	Journal of Safety Research
Abu Ashour et al. (2021)	Paratransit services for people with disabilities in the Seattle region during the COVID-19 pandemic: Lessons for recovery planning	Journal of Transport & Health
Liu and Liu (2021)	How does perceived accessibility influence mental health status during the covid-19 pandemic: the case of kunming, china	Journal of Transport & Health
Oviedo et al. (2021)	Covid-19, accessibility and well-being inequalities in latin america	Journal of Transport & Health
Tao and Cao (2021)	Exploring the interaction effect of poverty concentration and transit service on highway traffic during the COVID-19 lockdown	Journal of Transport and Land Use
Lou et al. (2020)	Are stay-at-home orders more difficult to follow for low-income groups?	Journal of Transport Geography
Hohenthal and Minoia (2021)	Territorial and mobility justice for Indigenous youth: accessing education in Ecuadorian Amazonia	Mobilities
Bracarense and de Oliveira (2021)	Access to urban activities during the Covid-19 pandemic and impacts on urban mobility: The Brazilian context	Transport Policy
Dong et al. (2021)	Understanding public transport satisfaction in post COVID-19 pandemic	Transport Policy
Gaskin et al. (2021)	Geographic disparities in COVID-19 infections and deaths: The role of transportation	Transport Policy
Kim et al. (2021a)	Identifying areas of potential critical healthcare shortages: A case study of spatial accessibility to ICU beds during the COVID-19 pandemic in Florida	Transport Policy
Valenzuela-Levi et al. (2021)	Housing and accessibility after the COVID-19 pandemic: Rebuilding for resilience, equity and sustainable mobility	Transport Policy
Chen et al. (2021a)	How is the COVID-19 pandemic shaping transportation access to health care?	Transportation Research Interdisciplinary Perspectives
Cochran (2020)	Impacts of COVID-19 on access to transportation for people with disabilities	Transportation Research Interdisciplinary Perspectives
Khaddar and Fatmi (2021)	COVID-19: Are you satisfied with traveling during the pandemic?	Transportation Research Interdisciplinary Perspectives
Liu et al. (2021b)	Smartphone-based services, perceived accessibility, and transport inequity during the COVID-19 pandemic: A cross-lagged panel study	Transportation Research Part D-Transport and Environment
Ghorbanzadeh et al. (2021)	Spatial accessibility assessment of COVID-19 patients to healthcare facilities: A case study of Florida	Travel Behaviour and Society
Urban space use & land use		
Georgouli et al. (2021)	How transport and urban planning priorities have changed during the covid-19 pandemic. driving factors of changes and barriers in dealing with crisis	Journal of Transport & Health
Scott (2021)	Shared streets, park closures and environmental justice during a pandemic emergency in Denver, Colorado	Journal of Transport & Health
Kim et al. (2021b)	Changes in car and bus usage amid the COVID-19 pandemic: Relationship with land use and land price	Journal of Transport Geography
Jensen (2021)	Pandemic disruption, extended bodies, and elastic situations-Reflections on COVID-19 and Mobilities	Mobilities
Combs and Pardo (2021)	Shifting streets COVID-19 mobility data: Findings from a global dataset and a research agenda for transport planning and policy	Transportation Research Interdisciplinary Perspectives
Corazza et al. (2021)	Chronicles from the new normal: Urban planning, mobility and land-use management in the face of the COVID-19 crisis	Transportation Research Interdisciplinary Perspectives
Shirgaokar et al. (2021)	Using twitter to investigate responses to street reallocation during COVID-19: Findings from the U.S. and Canada	Transportation Research Part A: Policy and Practice
Disease spread & inter/intra city mobility		
Fazio et al. (2021)	Agent-based modelling of mobility restrictions at a large scale: exploring the impact on the covid-19 spreading in italy	Journal of Transport & Health
Manout (2021)	The contribution of daily mobility and activities to the spread of covid-19: a case study from montreal, canada	Journal of Transport & Health
Wan (2021)	Impacts of intra-city and inter-city mobility restrictions on covid-19 transmission in china	Journal of Transport & Health
Li et al. (2021d)	Assessing regional risk of COVID-19 infection from Wuhan via high-speed rail	Transport Policy

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Zhang et al. (2021b)	Effects of transport-related COVID-19 policy measures: A case study of six developed countries	Transport Policy
Zhang et al. (2020b)	Exploring the roles of high-speed train, air and coach services in the spread of COVID-19 in China	Transport Policy
Ajide et al. (2020)	Estimating the impacts of lockdown on Covid-19 cases in Nigeria	Transportation Research Interdisciplinary Perspectives
Yilmazkuday (2020)	COVID-19 spread and inter-county travel: Daily evidence from the U.S	Transportation Research Interdisciplinary Perspectives
Lu et al. (2021)	Influence of transportation network on transmission heterogeneity of COVID-19 in China	Transportation Research Part C-Emerging Technologies
Yoo and Ross (2021)	Exploratory Study of Determinants of the Spread of COVID-19 before Shelter-in-Place Orders	Transportation Research Record
Others		
Susilo et al. (2021)	Six lessons from first year COVID-19 restrictions: what can we do better in the future?	European Transport Research Review
Arellana et al. (2020)	COVID-19 Outbreak in Colombia: An Analysis of Its Impacts on Transport Systems	Journal of Advanced Transportation
Duren et al. (2021)	Modeling state preferences for Covid-19 policies: Insights from the first pandemic summer	Journal of Transport & Health
Stavroulakis et al. (2021)	Transportation, the pathogen vector to rule them all: Evidence from the recent coronavirus pandemic	Journal of Transport & Health
Cairns et al. (2021)	An immobility turn? The Covid-19 pandemic, mobility capital and international students in Portugal	Mobilities
Pase et al. (2021)	Pandemic cartographies: a conversation on mappings, imaginings and emotions	Mobilities
Caballini et al. (2021)	Physical mobility and virtual communication in Italy: Trends, analytical relationships and policies for the post COVID-19	Transport Policy
Chen et al. (2021b)	Exploring essential travel during COVID-19 quarantine: Evidence from China	Transport Policy
Cui et al. (2021)	The impacts of COVID-19 pandemic on China ? s transport sectors based on the CGE model coupled with a decomposition analysis approach	Transport Policy
Marsden and Docherty (2021)	Mega-disruptions and policy change: Lessons from the mobility sector in response to the Covid-19 pandemic in the UK	Transport Policy
Zhang (2020)	Transport policymaking that accounts for COVID-19 and future public health threats: A PASS approach	Transport Policy
Zhang et al. (2021a)	COVID-19 and transport: Findings from a world-wide expert survey	Transport Policy
Zhou et al. (2021a)	Impacts of COVID-19 and anti-pandemic policies on urban transport-an empirical study in China	Transport Policy
Iacus et al. (2021)	Mobility functional areas and COVID-19 spread	Transportation
Osinska and Zalewski (2021)	Vulnerability and resilience of the road transport industry in Poland to the COVID-19 pandemic crisis	Transportation
Su and Goulias (2021)	Evolution of the Chinese spring festival travel network during the COVID-19 early outbreak	Transportation Letters
Chen and Pan (2020)	Transport-related experiences in China in response to the Coronavirus (COVID-19)	Transportation Research Interdisciplinary Perspectives
Kim (2021)	Impacts of COVID-19 on transportation: Summary and synthesis of interdisciplinary research	Transportation Research Interdisciplinary Perspectives
Lee and Lee (2020)	Testing on the move: South Korea's rapid response to the COVID-19 pandemic	Transportation Research Interdisciplinary Perspectives
Mogaji (2020)	Impact of COVID-19 on transportation in Lagos, Nigeria	Transportation Research Interdisciplinary Perspectives
Gupta and Perera (2021)	Managing surges in online demand using bandwidth throttling: An optimal strategy amid the COVID-19 pandemic	Transportation Research Part E-Logistics and Transportation Review
Abreu and Conway (2021)	A Qualitative Assessment of the Multimodal Passenger Transportation System Response to COVID-19 in New York City	Transportation Research Record
Bamney et al. (2021)	Examining Impacts of COVID-19-Related Stay-At-Home Orders through a Two-Way Random Effects Model	Transportation Research Record
Bian et al. (2021a)	Predicting Grocery Store Visits During the Early Outbreak of COVID-19 with Machine Learning	Transportation Research Record
Zhang et al. (2021c)	Interactive COVID-19 Mobility Impact and Social Distancing Analysis Platform	Transportation Research Record