Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Sustainable Cities and Society 67 (2021) 102729

Contents lists available at ScienceDirect

Sustainable Cities and Society

journal homepage: www.elsevier.com/locate/scs

Exploring geographical distribution of transportation research themes related to COVID-19 using text network approach

Boniphace Kutela [a,*], Norris Novat [b], Neema Langa [c]

[a] Roadway Safety Program, Texas A&M Transportation Institute, 1111 RELLIS Pkwy, Bryan, TX 77807, United States
[b] Department of Civil Engineering, Ardhi University, P.O. Box 35176, Dar es Salaam Tanzania
[c] Department of Sociology, University of Nevada, Las Vegas, 4505 S Maryland Pkwy, Las Vegas, NV 89154, United States

ARTICLE INFO

Keywords:
Text networks
COVID-19
Transportation
Machine learning
Bibliometric

ABSTRACT

The COVID-19 outbreak has extremely impacted the globe due to travel restrictions and lockdowns. Geographically, COVID-19 has shown disproportional impacts; however, the research themes' distribution is yet to be explored. Thus, this study explored the geographical distribution of the research themes that relate to COVID-19 and the transportation sector. The study applied a text network approach on the bibliometric data of over 400 articles published between December 2019 and December 2020. It was found that the researches and the associated themes were geographically distributed based on the events that took place in the respective countries. Most of the articles were published by the authors from four countries, the USA, China, Japan, and the UK. The text network results revealed that the USA-based studies mainly focused on international travelers, monitoring, travel impacts of COVID-19, and social-distancing measures. The Japanese-based studies focused on the princess diamond cruise ship incident. On the other hand, Chinese authors published articles related to travel to Wuhan and China, passenger health, and public transportation. The UK-based studies had diverse topics of interest. Lastly, the remaining 62 countries' studies focused on returning travelers from China, public transportation, and the global spread of COVID-19. The findings are crucial to the transportation sector's researchers for various applications.

1. Background

It has been about a year since the first asymptomatic case of COVID-19 was reported on 8th December 2019 in Wuhan, China (WHO, 2020a). COVID-19 outbreak was later declared as a pandemic in March 2020, after slightly more than 150,000 people were infected. As of December 2020, statistics show that over 70 million people have been infected, 49 million have been recovered, and about 1.5 million people have died of COVID-19 (Worldometer, 2020).

The geographical and chronological aspects of the COVID-19 revealed that by January 22, 2020, most Asian countries, including South Korea, Japan, Taiwan, India, and the Philippines had already reported their first cases (Sparke & Anguelov, 2020). COVID-19 cases were first reported in Europe on January 24th, in Bordeaux, and Paris; both involved patients who traveled from China (Fredericks, 2020). Parallel to that, on January 20th, the first known case of COVID-19 was confirmed in the State of Washington in the United States from a man who returned from Wuhan. Within a short time, the pandemic reached South America, whereby Brazil confirmed a case in São Paulo on February 26th (AS/COA, 2020). In Australia, the first case was reported to be on January 25th in Melbourne, Victoria (WHO, 2020b). Furthermore, in Africa, the early cases were reported in Egypt and Algeria on February 14th and 17th, respectively (WHO | Regional Office for Africa n.d. 2020). Contrary to other countries, most confirmed cases in African countries involved people traveling from Europe and the United States as opposed to China (Maclean, 2020).

Currently, almost all countries around the globe have been affected by COVID-19. However, the magnitude of the effect measured by the number of infected people varies per country. The United States is leading in terms of the number of infections and deaths (Fig. 1). Other countries with a large number of COVID-19 cases include India, Brazil, Russia, and Peru. South Africa is the only African country to be ranked in the top 10 for the number of COVID-19 cases.

Being a communicable disease, COVID-19 is easily transmitted through different transportation modes. Thus, the imposed spread control measures such as lockdowns and travel restrictions have greatly

* Corresponding author.
E-mail addresses: b-kutela@tti.tamu.edu (B. Kutela), n.novatbaraba@vikes.csuohio.edu (N. Novat), langan1@unlv.nevada.edu (N. Langa).

https://doi.org/10.1016/j.scs.2021.102729
Received 14 September 2020; Received in revised form 14 January 2021; Accepted 16 January 2021
Available online 23 January 2021

affected the transportation sector. Such impacts have prompted many researchers in the world to explore the implication of COVID-19 on transportation. Understanding how the transportation sector has aided the spread, as well as developing preventive measures, are among the few focus to mention (Clifford et al., 2020; Craig, Heywood, & Hall., 2020; Gostic et al., 2020). Their study (Craig et al., 2020) analyzed how travelers may introduce COVID-19 into the Pacific islands by using travel and Global Health Security Index data using a scoring tool to produce quantitative estimates. They found that the air routes with the highest risk to the Pacific islands are from East Asian countries (specifically, China, Korea, and Japan). Also, (Clifford et al., 2020) evaluated the effectiveness of thermal passenger screening at the airport exit and entry to inform public health decision-making. They estimated that 46 % (95 % confidence interval: 36–58) of infected travelers would not be detected, depending on the incubation period, the sensitivity of exit and entry screening, and the proportion of asymptomatic cases.

Although there is a geographical disproportion of the number of infected, deaths, and recovery of the individuals, limited literature describing the impact of such a disproportion on the transportation sector is available. In other sectors, however, a few studies exist that show the distribution of the research studies in response to the COVID-19 geographical impacts. A study by Rose-Redwood et al. (2020) discussed the geography of COVID-19 with a view of the extent of spread worldwide by exploring 42 commentaries written by contributors across the globe. Their study's findings are influenced by contributors' perceptions whose views are limited to their understanding and may differ from someone else. Also, a study by Sun, Matthews, Yang, & Ming-Hsiao (2020) explored the interconnections between countries and spatial structures in the prevalence of the pandemic by using a dataset of confirmed cases by June 28th. They found that spatial models can help partially explain the geographic disparities in COVID-19 period prevalence. Another study (Kuchler, Russel, & Stroebel, 2020) relied on social media analysis to forecast the geographic spread of communicable diseases such as COVID-19. The data set appears to be limited to two countries; USA and Italy and thus it cannot be concluded if the results can be extrapolated to other countries and specifically countries with little exposure to social media (Kuchler et al., 2020).

Therefore, this study applies the text mining approach to evaluate the themes of the COVID-19-Transportation published articles to explore their geographical distribution. The study also tries to answer a question regarding the influence of COVID-19 on the collaboration among authors as well as the key role played by the major developed countries to help COVID-19 researches in other developing countries. The practical importance of the methodology adopted for this research is the visualization from text networks, which give a thorough analysis of what is covered in the literature. This study views the pandemic from a wider spectrum of approaches and perspectives by different authors and countries. The geographical extent of this research will expose the global scholarly gap in the transportation field amidst the pandemic. And therefore, it helps track down how the world of transportation is impacted in different parts of the world but also understand what is currently known and what is yet to be studied globally as far transportation is concerned.

The proceeding sections presents the methodology that summarizes the approach used to explore the geographical publications on COVID-19 and Transportation. Then, the data description section, which introduces the study data sources used in the analysis, followed by a discussion of the results. The last section is the conclusion, which summarizes the manuscripts and presents the limitations and other areas of exploration.

2. Data and methodology

2.1. Data description

This study utilized a total of 488 Transporation-COVID-19 publications retrieved from reliable and up-to-date publication depositories, namely, Lit Covid (Chen, Allot, & Zhiyong, 2020) Stephen B. Thacker Center for Disease Control and Prevention (CDC) library (CDC, 2020), and Elsevier (Elsevier, 2020). The LitCovid (Chen et al., 2020) have articles that are updated daily and are further categorized by different research topics and geographic locations for improved access. The Stephen B. Thacker Center for Disease Control and Prevention (CDC) library (CDC, 2020) and (Elsevier, 2020) have more than 80,000 articles related to COVID-19 that are deposited and are freely available. The outstanding relevance of these depositories proves them credible for use in the study. The textual data from the database were published between 8th December 2019 and 8th December 2020; the latter publications from this date were therefore not considered.

COVID-19 and transportation-related manuscripts were explored in this study; a collective dataset with relevant keywords was assembled to extract transportation-related articles. The keywords such as; traveling, travelers, mobility, which are general transportation terms were used to search manuscripts that related COVID-19 to transportation. Further, airways, airport, airplane, flight, aircraft, air travel were used to search for airways travel mode. Additionally, ship, cruise, and boat were the keywords used to search for publications relating to COVID-19 and waterways mode. Subway, bus, train, rideshare, taxi, and bike were used to search for surface transportation. The search was followed by stratification by author country of affiliation and respective countries of case studies to narrow down the focus geographically.

The search resulted in a total of 488 articles. Fig. 2 shows the number

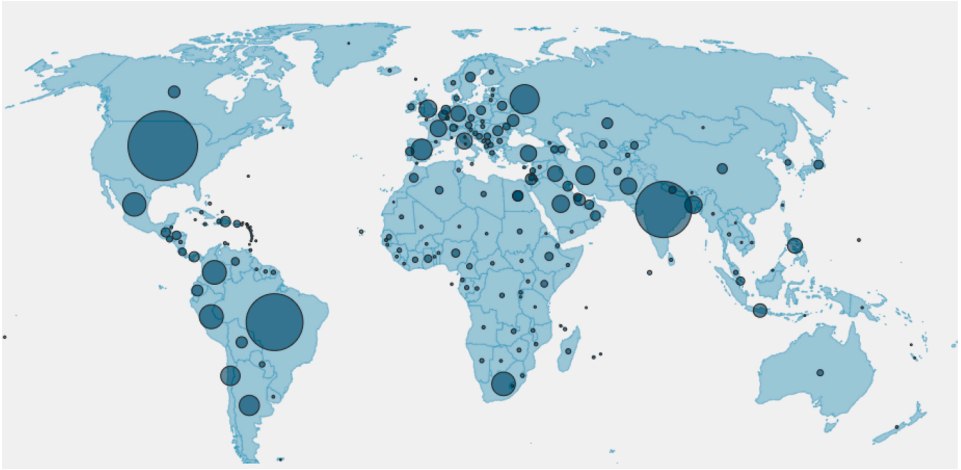


Fig. 1. COVID-19 Cases Across the Globe (BBC, 2020).

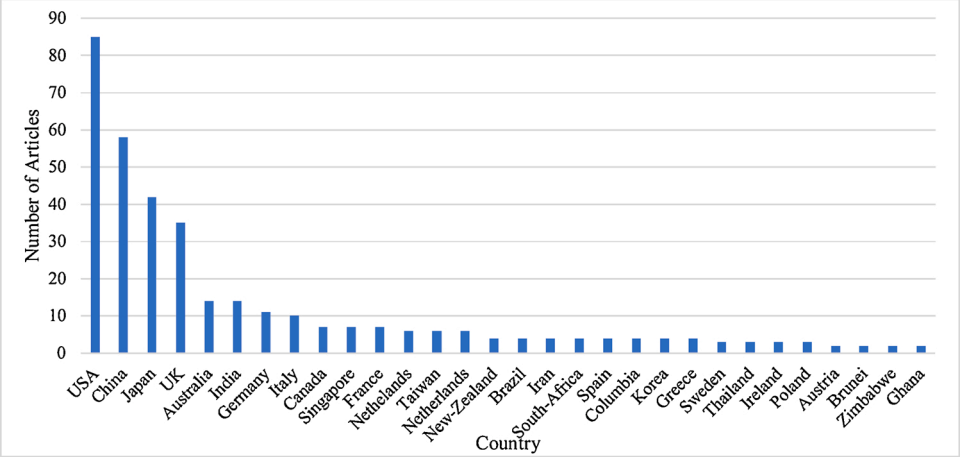


Fig. 2. Number of COVID-19-Transportation Articles by Country.

of COVID-19-Transporation publications from countries across the globe that have at least two publications. The figure appears to be skewed to the right having the long tail to the right of the graph; this accounts for the uneven distribution of manuscripts geographically.

The United States of America with 85 USA only publications and 131 in collaborations with others (equivalent to 26 % of all articles) is leading by far in article count, followed by China with 58 (18 %) Chinese based publications and 84 publications in collaboration with others, then Japan with 42 (13 %) publications and 57 articles in collaboration with others, and the UK with 35 (11.0 %) articles and 64 articles in collaborations with others. Additionally, the authors from the four countries collaborated with authors from other countries for a substantial number of articles. Additionally, authors from several other individual countries (62) contributed to a total of 186 (38 %) COVID-19-Transportation related articles.

2.2. Methodology

This study applied the text network approach to explore the geographical distribution as well as the differences in the contents of COVID-9-transportation-related literature per geographical area. The text network is a relatively new approach in transportation engineering, but it has been extensively used in other areas such as in literature and forensic studies (Paranyushkin, 2011), among others.

The text network analysis enables the extraction and interpretation of the textual data easily by considering the connections among the keywords; thus, it over-performs the frequency-based textual data analysis approaches. The text network's creation involves a few more extra steps than the one used in other text mining approaches. In general, text mining approaches involve text normalization and the creation of structured data from unstructured data. During text normalization, all stop words signs and symbols are removed, and capital letters are converted to small letters for uniform analysis. The creation of structured data involves the identification of the individual keywords by which several analyses can be performed. The extra step added for the text network is the network creation using a two-word gap or five-word gap approach. In this study, the two-word gap is used. In this approach, the predefined algorithms scan the sentence to determine consecutive keywords within a two-word window (Paranyushkin, 2011). The first obtained pair is mapped on the network, and then the algorithm continues to search for the next pair. If the same previously mapped pair is found, the algorithm assigns an additional weight/frequency of one on the existing pair of keywords (Fig. 3).

Else, if the new pair is obtained, the algorithm assigns a new node and an edge whose frequency is one (Fig. 3). It should be noted that the algorithm does not connect words from two different sentences

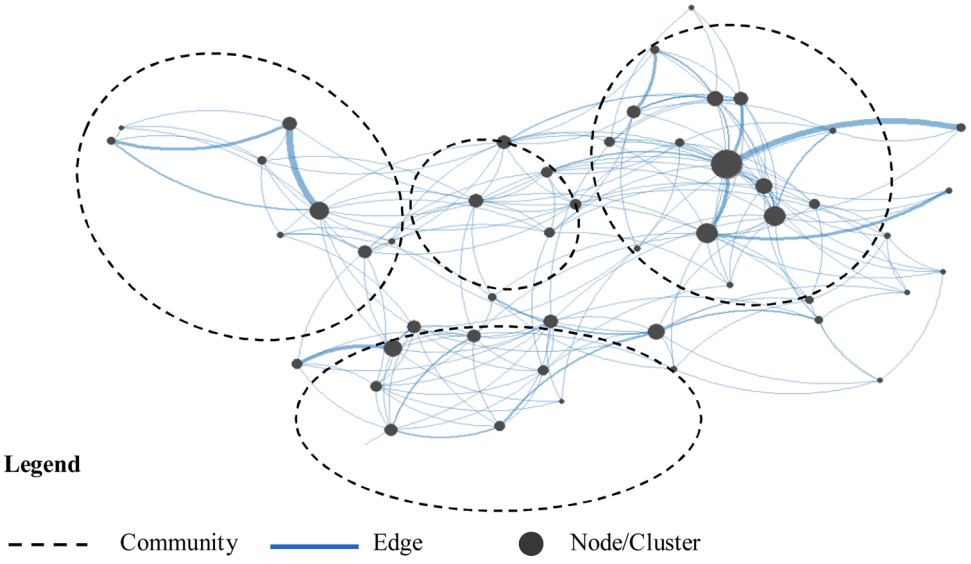


Fig. 3. Skeleton of the text network.

(Paranyushkin, 2011).

A complete text network has several nodes of different sizes and edges of different lengths and sizes. The nodes, also known as a cluster, are labeled by using their respective keywords. The larger the node/cluster, the more frequent the keyword, while the thicker the edge, the higher the frequency of the connected keywords. The length of the edge represents the distance between the keywords in a sentence. The shorter the edge in the text network, the closer the keywords in the sentence. Moreover, keywords with a similar pattern tend to form a group of interconnected clusters called a community.

Completion of the network allows the extraction of quantitative information for in-depth analysis and inferences (Yoon & Park, 2004). In this study, the interpretation is based on the size of the cluster and edges, as well as the topology of the entire network. Further, since the focus is on the major themes studied so far, the degree centrality, which quantifies the extent of connections between nodes was used to draw insights. It is computed by considering the number of edges that originate from one node to the other (Hansen, Shneiderman, Smith, & Himelboim., 2020) as shown in Eq. 1.

$$Degree\ centrality(i) = \sum_{j=1}^{l} c_{ij} \quad (1)$$

Where by, c_{ij} takes a value of 1 if nodes i and j, are connected, and 0 otherwise.

The entire analysis was performed in R-statistical software(R Core Team, 2020), using *quanteda* and *igraph* packages, respectively (Benoit et al., 2018; Csárdi, 2020). Considering the complexity of the network, only the top 50 keywords were used to draw insights.

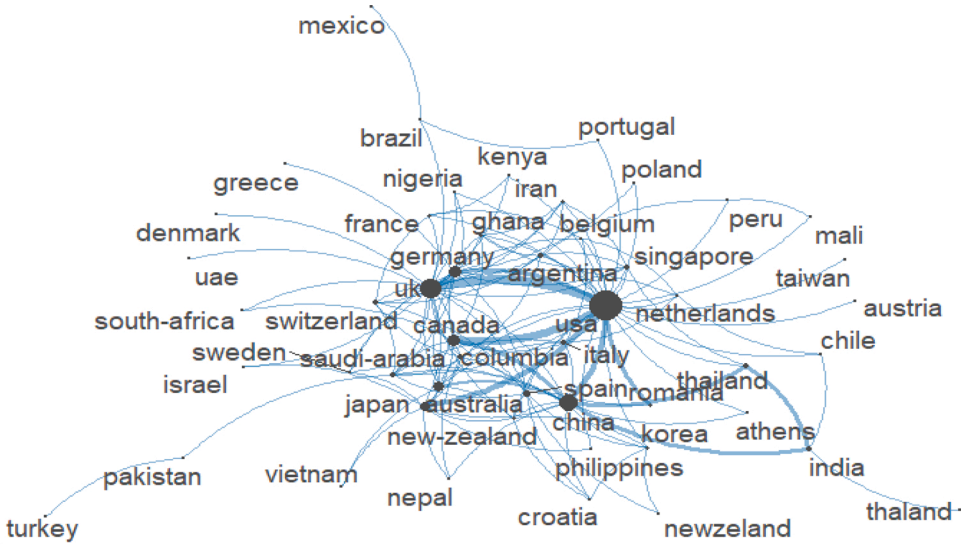
3. Results discussion

This section presents a thorough discussion of the text networks produced from the text mining of the COVID-19 and transportation literature. The dense networks portray meaningful insights on what was published and where it was published. The discussion is geographically consolidated by the deductions from the network of articles' authors, followed by Bibliometric networks of titles based on country affiliations. The manuscript geography discussion is presented from two perspectives. First, publications from countries with most publications namely, USA, China, UK, Japan and mixed countries. And second, the rest of the countries with low manuscript count are collectively discussed under the other countries section.

3.1. Geographical network of authors

The text network in Fig. 4 is a visualization of the author's countries of affiliation. The network presents a central community of keywords USA, UK, China, Canada and Japan. The network shows that most of the manuscripts were published by researchers from these five countries and that their nodes' close proximity and dense linkages explain their extent of collaborations. Generally, the network is centrally dominated by the keyword USA and most importantly, it appears to have the highest degree of centrality (32). The observation implies that USA based authors have the most outstanding collaboration with authors from other countries in the network.

Out of all the edges linked to USA, the ones extended to the nodes (UK, China, Canada, Japan, and Germany) appear to be the thickest, meaning that most of the USA authors' collaborations were with these particular researchers. Moreover, the connection to the five nodes listed above explains that the USA has comparable dense connections to the country that have suffered a comparable impact of COVID-19. Nevertheless, unlike other heavy nodes, the USA appears to have the most edge connections to the smaller nodes of the network, such as Taiwan, Mali, Peru, Portugal, Austria, etc. This shows the interest of researchers from the rest of the world to collaborate with USA researchers. The nodes UK and China also appear to be thick/dense, implying that there are a substantial number of authors from these countries who researched Transportation-COVID-19, which are also influenced by the high number of confirmed cases and mortalities between these two countries (Worldometer, 2020). However, despite the visibly dense connections of these nodes (Canada, UK and China) to the main node (USA), the node China is relatively closer to the node USA as compared to UK and Canada; this shows that the level of collaboration between the USA and China authors supersedes that of UK's and Canada's. On top of that, the presence of the country from each continent in the network shows a fair scholarly contribution across the globe. This accounts for a good research environment in exploring inter-country/continental transportation in the COVID-19 era. Comparatively, the little representation by authorship countries from some continents such as South America (Brazil, Peru, Chile, Colombia) and Africa (South-Africa, Ghana, Nigeria, Mali) compared to other continents like North America and Europe show



Keyword	USA	UK	China	Germany	Japan
Degree centrality	32	27	16	15	12

Fig. 4. A Text Network of Articles' Authors by Country of Affiliation.

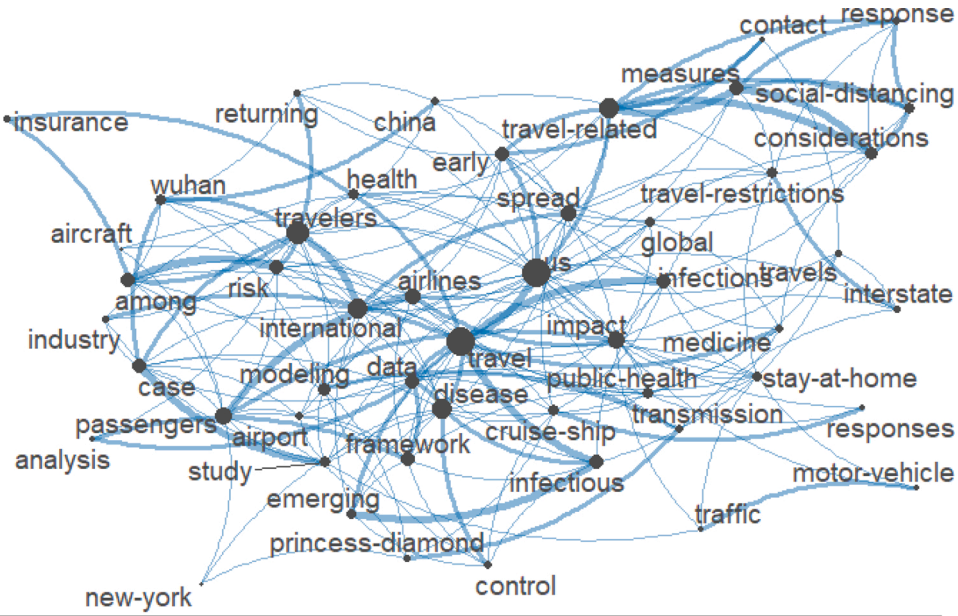
that limited research has been published from some continents. Lower cases and mortality figures confirmed in most developing countries especially in Africa, can explain this comparison (Worldometer, 2020). The measures of degree centrality among the most published author country also indicate that the USA (32) is leading followed by UK, China Germany, and Japan, explaining its extensive collaboration with other country's authors. Although Germany has a greater number of collaborated studies (Fig. 4), it has fewer number of total studies than Japan (Fig. 2).

3.2. The United States-based articles

Fig. 5 portrays the text network of keywords from the articles' titles by the authors from the United States. The table below the figure shows five keywords with the highest number of connections (degree centrality) to other keywords. A few communities of keywords can be observed from the text network. The first community at the top left of the network is centered on keyword travelers and is heavily linked to keywords international, returning, and wuhan, among others. This community implies that the majority of the researchers from the United States explored the relationship between the COVID-19 and the international travelers with a particular interest to those returning from Wuhan, China (Niehus, De Salazar, Taylor, & Lipsitch, 2020). Another community to the top right of the network is formed at the central keyword measures, which is heavily linked to the cluster's response, travel-related, considerations, and social-distancing, among others. The interpretation here is that the researchers focused their search on spread due to travel-related cases and assessed the imposed measures on social-distancing protocols and their respective public response (Gómez-Ríos, Ramirez-Malule, & Ramirez-Malule, 2020; Mogaji, 2020). In addition to that, a community at the center of the network represented by the keywords travel, US, travel-restrictions, infections shows that further considerable research is done on spreading due to traveling (Niehus et al., 2020). The keyword travel-restrictions shows that some publications covered the impact of travel restrictions on limiting the spread of COVID-19 (Chinazzi et al., 2020; Meier, Habibi, & Tony Yang, 2020). However, the clusters (travel, health, and insurance) are likely connected, suggesting that some researchers explored the health insurance mechanisms that can guarantee safe traveling. Additionally, the network presents the nodes modeling, data and transmission which describes the work done by researchers in modeling the transmission of the diseases (Zhuang et al., 2020). The degree of centrality measures for some of the heaviest nodes in the network also justify the extent of the areas covered in USA based articles, as equivalent to their node sizes US (25) is leading by far followed by International (17), travel (16), travelers (15) and impact (14). This highlights the most important keywords and areas covered in the USA articles.

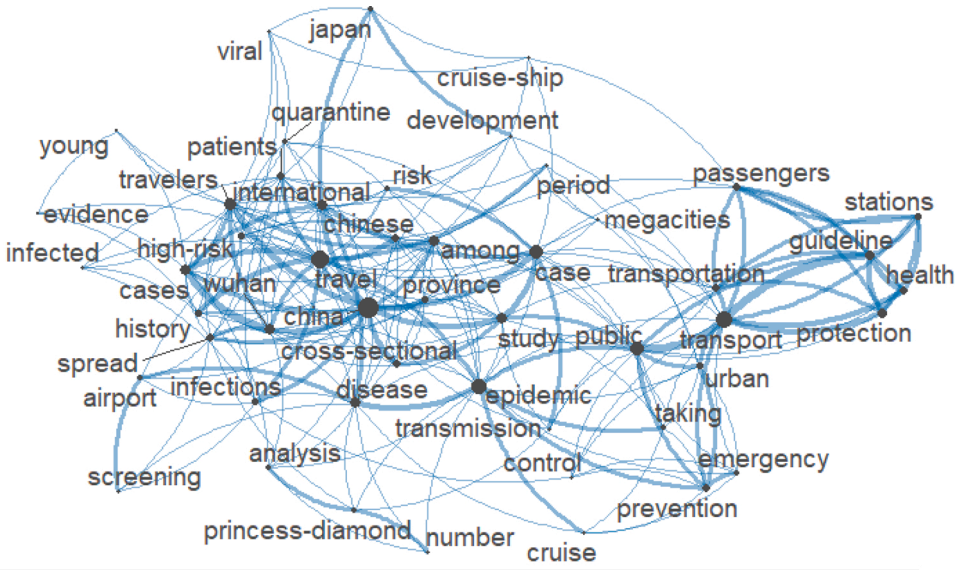
3.3. The China-based articles

The text network of the titles for the Chinese-based publications is presented in Fig. 6. The network is dominated by two communities. The one to the far right of the network is formed by keywords (health, public, transport, guideline, stations passenger, protection). This shows that some researchers had a particular interest in public transportation connection to COVID-19 (Mizumoto, Kagaya, Zarebski, & Chowell, 2020). The second community is the one to the left formed by major keywords China, travel, travelers, international, cases, Wuhan, and other minor keywords. The center of the network has two heavy nodes travel and China outwardly connected to many other keywords. For instance, the linkage (China- travelers, China- Travel) shows that majority of Chinese-based publications were focused on traveling to/from China (Chinazzi et al., 2020; Shi et al., 2020). Parallel to that, the dense link (China-International) highlights that most researchers linked the International spread of the pandemic to China in the quest to understand the pandemic (Lai et al., 2020; Staff, 2020; Zhong, Guo, & Chen, 2020). Also, the link (China-province) shows these researchers focused their search on the provinces where the break out is traced such as Wuhan and Macao (Lio et al., 2020). The heavy node travel has heavy links with travel-high-risk, travel-history signifying that some researchers tried to understand the pandemic by studying passengers' travel history and their prominent risks (Ceder & Jiang 2020; Shi et al., 2020). Their degree centrality measures values also explain the linkages of the mentioned nodes, keyword travel (21) is leading followed by China (20), epidemic (20), travelers (17) and case (17



Keyword	US	international	travel	travelers	impact
Degree centrality	25	17	16	15	14

Fig. 5. USA-based Article Titles' Network.



Keyword	travel	China	epidemic	travelers	case
Degree centrality	21	20	20	17	17

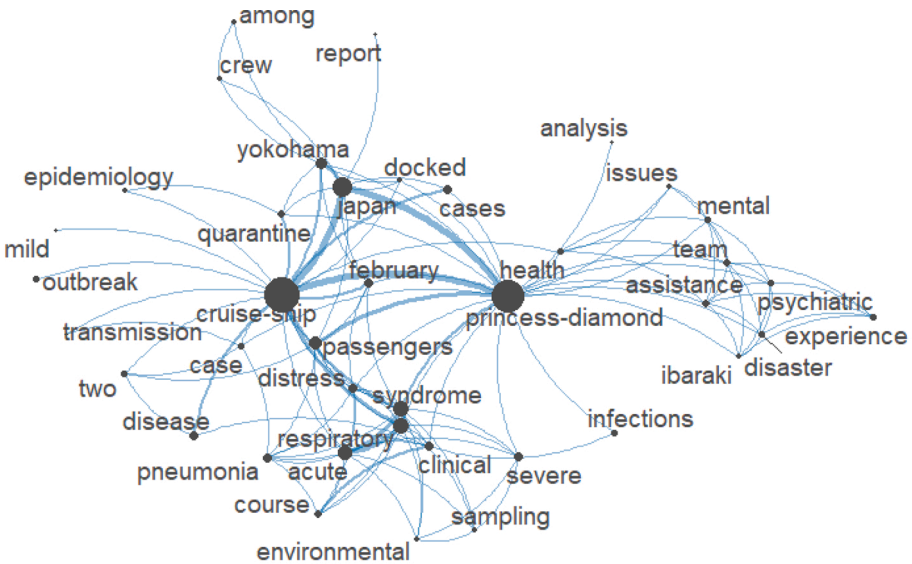
Fig. 6. China-based Article Titles' Network.

3.4. Japan-based articles

The text networks presented in Fig. 7 describe the keywords for the articles' titles whose authors are based in Japan. A vivid community of highest degree centrality (cruise-ship, princess-diamond, and Japan) appears to be at the center of this network topology. The implication is that the authors focused more on the famous Diamond Cruise ship incident that occurred in Japan (Anan et al., 2020; Sekizuka et al., 2020; Zhang et al., 2020). Moreover, the bottom of the network presents a community formed by keywords (acute, environmental, syndrome, mild, respiratory). The implication here is that some researchers tried to link the mild respiratory symptoms to environmental sanitation, and some tried to explore the possibility of limiting the spread by sanitizing the environment (Hirotsu et al., 2020). Nevertheless, the use of such keywords highlights that some studies in Japan had initially perceived the pandemic as a mild respiratory syndrome (Arashiro, Furukawa, & Nakamura., 2020). This network's important keywords also have the highest degree centrality measures showing their higher level of association with other keywords and their in-depth coverage. The keyword cruiseship (38) is leading by followed by princess-diamond (37), japan (24), passengers (18) and respiratory (17).

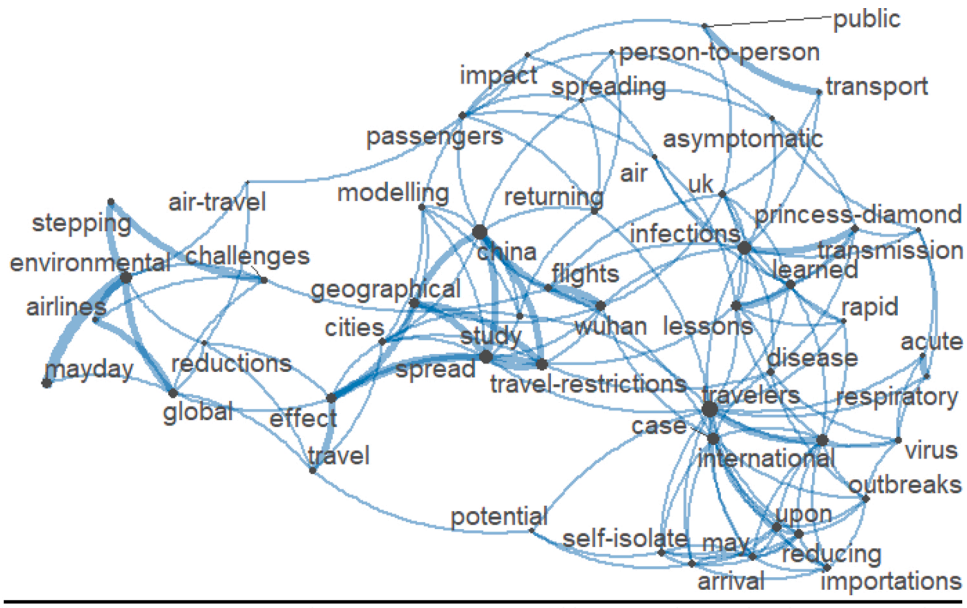
3.5. The UK-based articles

Fig. 8 presents the text networks and the topmost associated degree centralities for the UK-based publications. The text network shows notable sparsely communities, which accounts for a larger difference in perspectives of the studies covered. The community formed by keywords environmental, challenges, airlines, global imply that researchers focused on environmental challenges posed by COVID-19 in global



Keyword	cruise-ship	princess-diamond	japan	passengers	respiratory
Degree centrality	38	37	24	18	17

Fig. 7. Japan-based Article Titles' Network.

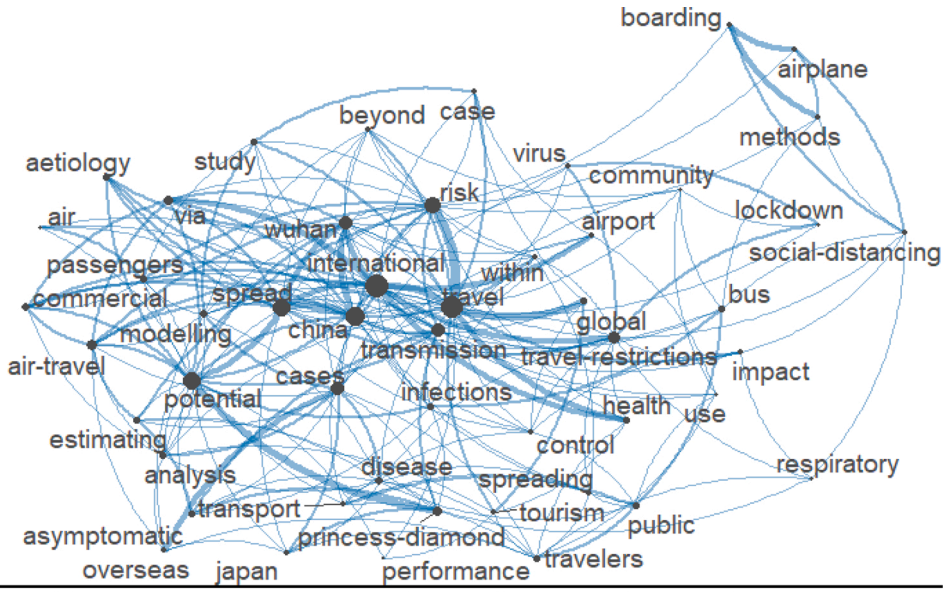


Keyword	travelers	case	China	international	spread
Degree centrality	15	12	10	10	9

Fig. 8. The UK-based Article Titles' Network.

airlines (Amankwah-Amoah, 2020). Two communities appear to the right of the network; one is centered on the clusters travelers, international, and case and the other is centered on the clusters infections, learned, lessons. The former accounts for the publications made in the quest to understand the needed preventive resources for both travelers and practitioners during the pandemic (Chiodini, 2020). While the latter accounts for some UK-based researchers trying to understand the transmission of COVID-19 by evaluating the lessons learned from the outbreak on the Diamond Princess cruise ship (Sawano et al., 2020; Schwedhelm et al., 2020; Vanderslott & Marks, 2020; Xu, Peng, Wang, & Yang., 2020).

Similarly, the mid-block is dominated by one community formed by keywords travel, effect, travel-restriction, spread, geographical, and china, this implies that the researchers studied the outcomes of geographical travel restrictions and had China as their case study (Fang, Wang, & Yang, 2020). And the latter shows us that some publications covered the estimation of spread from people interaction with returning travelers from china (Teherán et al., 2020). The degree of centrality values of the heaviest keywords also explains their significance and level of association with other keywords in the network, keyword travelers (15) is leading followed by keywords case (12), china (10), international (10), spread (9).



Keyword	china	international	travel	risk	spread
Degree centrality	22	22	22	20	18

Fig. 9. Network for Collaboration Publications Titles *(USA, UK, China, Japan, and their collaborators)*.

3.6. The collaborated articles (USA, UK, China, Japan, and their collaborators)

Given the outstanding authorship collaboration from different countries across the globe as elaborated from Fig. 4, the text networks in Fig. 9 describe the mixed countries' context.

The text network reveals several heavy nodes (*international, travel, China, and spread*) that are well connected to the rest of the network. First, the heaviest node (*international)* appears to have a dense connection to the keyword (*travel-restrictions)*. The connection shows that researchers explored the effects of travel restrictions that have been issued worldwide (Devi, 2020). The node *international* is also linked to the nodes *China, Wuhan, spread, and potential*; it is then fair to say a significant number of studies explored the causes of the potential spread of the outbreak in Wuhan, China and internationally. Additionally, the network presents another heavy keyword *travel,* which has a central connection to keywords *global, pandemic,* and *health,* among others. The deduction here is that many of these publications centered their thoughts on safe traveling (Bonilla-Aldana et al., 2020; Errett, Sauer, & Rutkow, 2020; Nakazawa, Ino, & Akabayashi, 2020). Further, the themes related to the princess diamond cruise ship appear in this network as shown by the node princess-diamond. The node is connected to Japan where the princess diamond cruise ship incident occurred Japan (Anan et al., 2020; Sekizuka et al., 2020; Zhang et al., 2020). The heaviest nodes of the network also have a high degree of centrality measures value explaining their in-depth coverage In these articles, the keyword *china (22)* is leading, followed by keywords *international(22), travel (22), risk (20)* and spread *(18)*.

3.7. Other countries articles

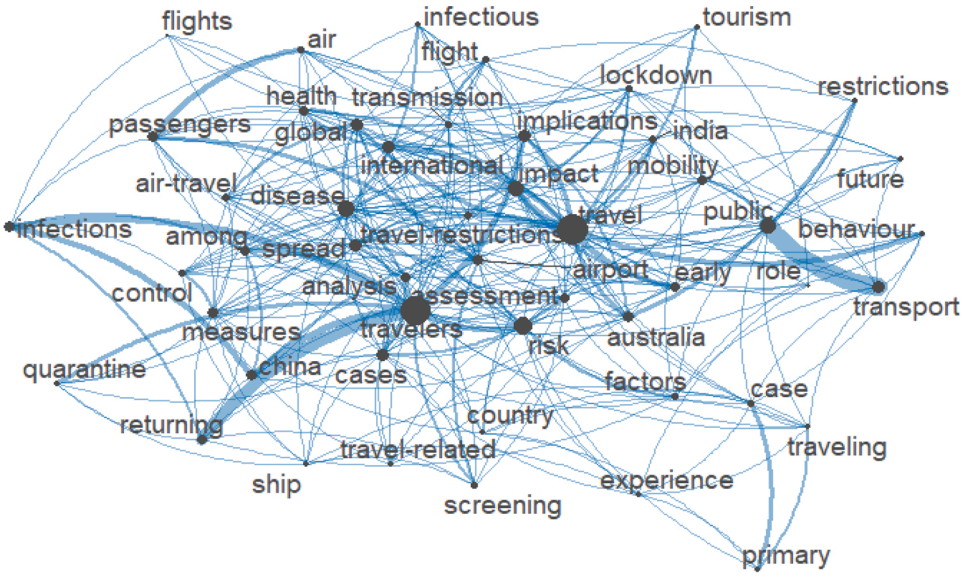
The text networks in Fig. 10 presents keywords for the publications whose authors are from other countries than the aforementioned above.

The text network has the keyword travel as the highest degree centrality node. It highlights the fact that traveling is indeed the focal point of the studies. Not only travel and travelers are the largest nodes, but also heavily associated with other clusters in the network. The keyword travelers is linked to nodes infections, China, returning, screening, risk and airport. The key implications from this linkage are; First, the majority of researches seek to explore the COVID-19 infection among travelers returning from Wuhan, China (Hoehl et al., 2020; Ng et al., 2020; Tian et al., 2020). Second, some of these publications focused their search on the screening process and its efficiencies at the airports (Quilty, Clifford, Flasche, & Eggo, 2020). The dense linkages on keyword travel, are to clusters airport, implications, behavior, impact and risk, among others. This community suggests that a significant number of researchers focused specifically on air travel, whereby the risk and impacts of air travel on the global spreading of the COVID-19 pandemic were assessed (Craig et al., 2020; Myers et al., 2020). Moreover, the impact of COVID-19 on sustainable means of transportation such as Bike-Sharing was assessed (Nikiforiadis, Ayfantopoulou, & Stamelou, 2020). The network also shows that some researches explored the travel behavior and patterns of passengers to help understand the spread of the disease by traveling (Chebli & Said, 2020; Fouquet & O'Garra, 2020; Li, Nguyen, & Andres Coca-Stefaniak, 2020; Neuburger & Egger, 2020; Shakibaei, de Jong, Alpkökin, & Rashidi, 2020). The network also presents the densest connection public – transport which explains the gravity of research work done on the disease spread through public transport (Anan et al., 2020; Beria & Lunkar, 2020; Coppola & Fabiis, 2020; Zhen et al., 2020). Various aspects of sustainable designs and strategic responses for public transport that are linked to COVID-19 are discussed (Cartenì, D'Acierno, & Gallo, 2020; Tirachini & Cats, 2020).

Further, lockdown and mobility also appear in the network, which suggests that a significant number of researchers focused on the impact of lockdown on the mobility of people (Beria & Lunkar, 2020). The degree centrality measures of the heaviest nodes of the network also signify their in-depth coverage by the researchers by other countries with keyword travel (31) leading followed by disease (29), travelers (28), cases (23) and risk (23).

4. Conclusions and future works

The literature on COVID-19 has been growing at a rather alarming rate since its outbreak in December 2019. COVID-19 has shown to have a disproportional geographical impact. As a result, the majority of the researchers link the pandemic aftermath effects to various other aspects of life in their geographical locations of interest. This particular study collected several publications from some well-founded depositories such as the CDC, Elsevier, and Lit Covid to demonstrate the geographical



Keyword	travel	disease	travelers	cases	risk
Degree centrality	31	29	28	23	23

Fig. 10. Other Countries-based Article Titles Network.

distribution, extent, and scope of the scholarly research efforts on COVID-19-Transportation. The study applied the text network approach to the titles of over 400 transportation-related articles.

It was found the publications are geographically stratified. The developed countries, notably; the USA, China, Japan, and the UK, dominated the researches. However, it can be argued that urgent extensive studies have been made in these countries, given their substantial transportation networks and infrastructures as compared to the rest of the world. Further, the authors from the four countries have collaborated with the authors from other numerous countries. Since fewer studies have been performed in developing countries, it is fair to conclude that little is known of the Transportation-COVID-19 circumstances in developing countries.

The study found that majority of these publications had a common interest, which is the risk of spreading the disease through human mobility. Therefore, it was a common resolution for most researchers to explore the effectiveness of travel restrictions in the hope of limiting the spread. It is also commonly observed that most of these publications linked their findings to China and particularly the city of Wuhan. The common conception here is that the pandemic originates from China. Consequently, some of the authors chose to link each COVID-19 confirmed case travel history to China as well as estimating the extent of spread from person to person contact with regards to returning travelers from China. Additionally, many authors explored the absolute risk of contagion and restrictions or regulations on public transportation use as it is highly dependent on the disease prevalence in the community at any specific time and the phase of the outbreak.

Moreover, the geographical distribution of the research themes is observed. Authors from the USA focused their exploration on travelers with respect to their origins and destinations of traveling, protective mechanisms such as screening and social distancing. While the Japanese based authors greatly explored the circumstances of COVID-19 and the Diamond Princess Cruise ship. However, the Chinese-based studies centered their research on Wuhan, China, as well as spread preventive guidelines and public transportation. Furthermore, great concern on the global spread of the pandemic, traveling to and from China, and risks of air transportation were made by the rest of the remaining countries (62). The geographical theme distribution is attributed to the nature of impact a particular country has endured with respect to the pandemic.

While this study's results offer some insights into the geographical distribution of the themes of COVID-19-transportation research, some limitations could be addressed in further research. Firstly, this study focused on exploring the publication through text mining and visualizations of the contexts sourced from some of the most renowned depositories. The results, however, cannot be extrapolated to the contexts from other depositories. Secondly, this research is bounded within the transportation sector's reach as it is undoubtedly the most pandemic linked sector next to the health, financial, and social-economic fields. Nevertheless, few to none of the published literature cover in-depth all modes of transportation as well as the adversity that they are enduring. Furthermore, regardless of the geographical theme distribution, less has been covered on sustainable transportation means such as bikeshare systems.

Declaration of Competing Interest

There is no conflict of interest.

References

Avi Ceder, A., & Jiang, Y. (2020). Route guidance ranking procedures with human perception consideration for personalized public transport service. *Transportation Research Part C: Emerging Technologies, 118*, 102667. https://doi.org/10.1016/j.trc.2020.102667

Amankwah-Amoah, J. (2020). Stepping up and stepping out of COVID-19: New challenges for environmental sustainability policies in the global airline industry. *Journal of Cleaner Production, 271*, 123000. https://doi.org/10.1016/j.jclepro.2020.123000

Anan, H., et al. (2020). Medical transport for 769 COVID-19 patients on a cruise ship by Japan disaster medical assistance team. *Disaster Medicine and Public Health Preparedness, 271*, 123000. https://doi.org/10.1016/j.jclepro.2020.123000

Arashiro, T., Furukawa, K., & Nakamura, A. (2020). COVID-19 in 2 persons with mild upper respiratory symptoms on a cruise ship, Japan. *Emerging Infectious Diseases, 26*(6), 1345–1348. https://doi.org/10.3201/eid2606.200452

AS/COA. (2020). *The coronavirus in Latin America*.

BBC. (2020). *Coronavirus pandemic: Tracking the global outbreak - BBC news*. September 5, 2020 https://www.bbc.com/news/world-51235105.

Benoit, K., et al. (2018). Quanteda: An R package for the quantitative analysis of textual data. *The Journal of Open Source Software, 3*(30). https://doi.org/10.21105/joss.00774. April 27, 2020.

Beria, P., & Lunkar, V. (2020). Presence and mobility of the population during the first wave of Covid-19 outbreak and lockdown in Italy. *Sustainable Cities and Society*, Article 102616.

Bonilla-Aldana, D. K., et al. (2020). Coronavirus infections reported by ProMED, February 2000–January 2020. *Travel Medicine and Infectious Disease*.

Cartenì, A., D'Acierno, L., & Gallo, M. (2020). A rational decision-making process with public engagement for designing public transport services: A real case application in Italy. *Sustainability (Switzerland), 12*(16), 6303. December 20, 2020 www.mdpi.com/journal/sustainability.

CDC. (2020). *COVID-19 research articles downloadable database*. August 23, 2020 https://www.cdc.gov/library/researchguides/2019novelcoronavirus/researcharticles.html.

Chebli, A., & Ben Said, F. (2020). The impact of Covid-19 on tourist consumption behaviour : A perspective article. *Journal of Tourism Management Research, 7*(2), 196–207. https://doi.org/10.18488/journal.31.2020.72.196.207

Chen, Q., Allot, A., & Zhiyong, L. (2020). Keep up with the latest coronavirus research. *Nature, 579*(7798), 193.

Chinazzi, M., et al. (2020). The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. *Science*.

Chiodini, J. (2020). Maps, masks and media – Traveller and practitioner resources for 2019 novel coronavirus (2019-NCoV) acute respiratory virus. *Travel Medicine and Infectious Disease, 33*, 101574. https://doi.org/10.1016/j.tmaid.2020.101574

Clifford, S., et al. (2020). Effectiveness of interventions targeting air travellers for delaying local outbreaks of SARS-CoV-2. *Journal of Travel Medicine, 27*(5). https://doi.org/10.1093/jtm/taaa068

Coppola, P., & De Fabiis, F. (2020). Evolution of mobility sector during and beyond Covid-19: Viewpoint of industries, consultancies and public transport companies. *Tema-Journal of Land Use Mobility and Environment*, 81–90. https://doi.org/10.6092/1970-9870/6900

Craig, A. T., Heywood, A. E., & Hall, J. (2020). Risk of COVID-19 importation to the pacific islands through global air travel. *Epidemiology and Infection, 148*, Article e71. https://doi.org/10.1017/S0950268820000710

Csárdi, Gábor. (2020). Igraph. *Network analysis and visualization*.

Devi, S. (2020). Travel restrictions hampering COVID-19 response. *Lancet, 395*(10233), 1331–1332. https://doi.org/10.1016/S0140-6736(20)30967-3

Elsevier. (2020). *Novel coronavirus information center*. August 23, 2020 https://www.elsevier.com/connect/coronavirus-information-center.

Errett, N. A., Sauer, L. M., & Rutkow, L. (2020). An integrative review of the limited evidence on international travel bans as an emerging infectious disease disaster control measure. *Journal of Emergency Management, 18*(1), 7–14. https://doi.org/10.5055/jem.2020.0446

Fang, H., Wang, L., & Yang, Y. (2020). Human mobility restrictions and the spread of the novel coronavirus (2019-NCoV) in China. *Journal of Public Ecionomics, 191*, 104272. https://doi.org/10.1016/j.jpubeco.2020.104272

Fouquet, R., & O'Garra, T. (2020). The behavioural, welfare and environmental effects of air travel reductions during and beyond COVID-19. *SSRN Electronic Journal. Working Paper No. 372*.

Fredericks, B. (2020). WHO says Europe is new epicenter of coronavirus pandemic. *New York Post*. https://nypost.com/2020/03/13/who-says-europe-is-new-epicenter-of-coronavirus-pandemic/.

Gómez-Ríos, D., Ramirez-Malule, D., & Ramirez-Malule, H. (2020). The effect of uncontrolled travelers and social distancing on the spread of novel coronavirus disease (COVID-19) in Colombia. *Travel Medicine and Infectious Disease, 35*, 101699. https://doi.org/10.1016/j.tmaid.2020.101699

Gostic, K., et al. (2020). Estimated effectiveness of traveller screening to prevent international spread of 2019 novel coronavirus (2019-NCoV). *medRxiv : The Preprint Server For Health Sciences*. https://doi.org/10.1101/2020.01.28.20019224

Hansen, D. L., Shneiderman, B., Smith, M. A., & Himelboim, I. (2020). Social network analysis: Measuring, mapping, and modeling collections of connections. *Analyzing social media networks with NodeXL* (pp. 31–51). Elsevier.

Hirotsu, Y., et al. (2020). Environmental cleaning is effective for the eradication of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in contaminated hospital rooms: A patient from the diamond princess cruise ship. *Infection Control and Hospital Epidemiology, 41*(9), 1105–1106. https://doi.org/10.1017/ice.2020.144

Hoehl, S., et al. (2020). Evidence of SARS-CoV-2 infection in returning travelers from Wuhan, China. *The New England Journal of Medicine, 382*(13), 1278–1280. https://doi.org/10.1056/NEJMc2001899. August 12, 2020.

Kuchler, T., Russel, D., & Stroebel, J. (2020). *The geographic spread of COVID-19 correlates with structure of social networks as measured by facebook*.

Lai, S., et al. (2020). Assessing spread risk of Wuhan novel coronavirus within and beyond China, january-april 2020: A travel network-based modelling study. *medRxiv*

: *The Preprint Server For Health Sciences*. https://doi.org/10.1101/2020.02.04.20020479

Li, J., Nguyen, T. H. H., & Andres Coca-Stefaniak, J. (2020). Coronavirus impacts on post-pandemic planned travel behaviours. *Annals of Tourism Research*, 102964. https://doi.org/10.1016/j.annals.2020.102964

Lio, C. F., et al. (2020). The common personal behavior and preventive measures among 42 uninfected travelers from the Hubei Province, China during COVID-19 outbreak: A cross-sectional survey in Macao SAR, China. *PeerJ., 8*, Article e9428. https://doi.org/10.7717/peerj.9428

Maclean, R. (2020). *Africa braces for coronavirus, but slowly - the new york times*.

Meier, B. M., Habibi, R., & Tony Yang, Y. (2020). Travel restrictions violate international law. *Science, 367*(6485), 1436. https://doi.org/10.1126/science.abb6950

Mizumoto, K., Kagaya, K., Zarebski, A., & Chowell, G. (2020). *medRxiv estimating the asymptomatic proportion of 2019 novel coronavirus onboard the princess cruises ship, 2020*.

Mogaji, E. (2020). Impact of COVID-19 on transportation in Lagos, Nigeria. *Transportation Research Interdisciplinary Perspectives, 6*, 100154. https://doi.org/10.1016/j.trip.2020.100154

Myers, J. F., et al. (2020). Identification and monitoring of international travelers during the initial phase of an outbreak of COVID-19 — California, February 3–March 17, 2020. *MMWR Morbidity and Mortality Weekly Report, 69*(19), 599–602.

Nakazawa, E., Ino, H., & Akabayashi, A. (2020). Chronology of COVID-19 cases on the diamond princess cruise ship and ethical considerations: A report from Japan. *Disaster Medicine and Public Health Preparedness, 14*(4), 1–8.

Neuburger, L., & Egger, R. (2020). Travel risk perception and travel behaviour during the COVID-19 pandemic 2020: A case study of the DACH region. *Current Issues in Tourism*, 14. https://doi.org/10.1080/13683500.2020.1803807

Ng, O. T., et al. (2020). SARS-CoV-2 infection among travelers returning from Wuhan, China. *The New England Journal of Medicine, 382*, 1476–1478. https://doi.org/10.1056/NEJMc2003100

Niehus, R., De Salazar, P. M., Taylor, A. R., & Lipsitch, M. (2020). Using observational data to quantify bias of traveller-derived COVID-19 prevalence estimates in Wuhan, China. *The Lancet Infectious Diseases, 20*(7), 803–808. https://doi.org/10.1016/S1473-3099(20)30229-2

Nikiforiadis, A., Ayfantopoulou, G., & Stamelou, A. (2020). Assessing the Impact of COVID-19 on bike-sharing usage: The case of Thessaloniki, Greece. *Sustainability, 12*(19), 8215. December 20, 2020 https://www.mdpi.com/2071-1050/12/19/8215.

Paranyushkin, D. (2011). Identifying the pathways for meaning circulation using text network analysis. *Venture Fiction Practices, 2*(4). April 27, 2020 www.noduslabs.com.

Quilty, B. J., Clifford, S., Flasche, S., & Eggo, R. M. (2020). Effectiveness of airport screening at detecting travellers infected with novel coronavirus (2019-NCoV). *Eurosurveillance, 25*(5).

R Core Team. (2020). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. November 17, 2018 https://www.r-project.org/.

Rose-Redwood, R., et al. (2020). Geographies of the COVID-19 pandemic. *Dialogues in Human Geography, 10*(2), 97–106.

Sawano, T., et al. (2020). Limiting spread of COVID-19 from cruise ships: Lessons to be learnt from Japan. *QJM : Monthly Journal of the Association of Physicians, 113*(5), 309–310. https://doi.org/10.1093/qjmed/hcaa092

Schwedhelm, M. M., et al. (2020). Can you catch it? Lessons learned and modification of ed triage symptom- and travel-screening strategy. *Journal of Emergency Nursing, 46*(6), 932–940. https://doi.org/10.1016/j.jen.2020.03.006

Sekizuka, T., et al. (2020). Haplotype networks of SARS-CoV-2 infections in the diamond princess cruise ship outbreak. *Proceedings of the National Academy of Sciences*.

Shakibaei, S., de Jong, G. C., Alpkökin, P., & Rashidi, T. H. (2020). Impact of the COVID-19 pandemic on travel behavior in Istanbul: A panel data analysis. *Sustainable Cities and Society*, 102619. https://doi.org/10.1016/j.scs.2020.102619. December 10, 2020.

Shi, S., et al. (2020). Travel restrictions and Sars-Cov-2 transmission: An effective distance approach to estimate impact. *Bulletin of the World Health Organization, 98*(8), 518–529. https://doi.org/10.2471/BLT.20.255679

Sparke, M., & Anguelov, D. (2020). Contextualising coronavirus geographically. *Transactions of the Institute of British Geographers, 45*(3), 498–508. https://doi.org/10.1111/tran.12389

Staff, S. (2020). Pressure grows on China for independent investigation into pandemic's origins. *Science*. https://www.sciencemag.org/news/2020/05/pressure-grows-china-independent-investigation-pandemic-s-origins.

Sun, F., Matthews, S. A., Yang, T.-C., & Ming-Hsiao, H. (2020). A spatial analysis of COVID-19 period prevalence in US counties through June 28, 2020: Where geography matters? *Annals of Epidemiology, 52*, 54–59. https://doi.org/10.1016/j.annepidem.2020.07.014. e1.

Teherán, A. A., et al. (2020). Presumptive asymptomatic COVID-19 carriers' estimation and expected person-to-Person spreading among repatriated passengers returning from China. *Travel Medicine and Infectious Disease, 37*, 101688. https://doi.org/10.1016/j.tmaid.2020.101688

Tian, H., et al. (2020). Early evaluation of the wuhan city travel restrictions in response to the 2019 novel coronavirus outbreak. *medRxiv*. https://doi.org/10.1101/2020.01.30.20019844

Tirachini, A., & Cats, O. (2020). COVID-19 and public transportation: Current assessment, prospects, and research needs. *Journal of Public Transportation, 22*(1), 1–34. https://doi.org/10.5038/2375-0901.22.1.1. December 20, 2020.

Vanderslott, S., & Marks, T. (2020). Travel Restrictions as a Disease Control Measure: Lessons from Yellow Fever. *Global Public Health*. https://doi.org/10.1080/17441692.2020.1805786

WHO. (2020a). *WHO | novel coronavirus – China*. WHO.

WHO. (2020b). *WHO coronavirus disease (COVID-19) dashboard | WHO coronavirus disease (COVID-19) dashboard*.

Worldometer. (2020). *Coronavirus update (live): 20,521,644 cases and 745,918 deaths from COVID-19 Virus Pandemic - worldometer*. August 11, 2020 https://www.worldometers.info/coronavirus/.

Xu, L., Peng, J., Wang, M., & Yang, J. (2020). Lessons and suggestions to travelers and cruise ships in the fight against COVID-19. *QJM: An International Journal of Medicine*, 1–2. https://doi.org/10.1093/qjmed/hcaa270

Yoon, B., & Park, Y. (2004). A text-mining-based patent network: Analytical tool for high-technology trend. *The Journal of High Technology Management Research, 15*(1), 37–50.

Zhang, S., et al. (2020). Estimation of the reproductive number of novel coronavirus (COVID-19) and the probable outbreak size on the diamond princess cruise ship: A data-driven analysis. *International Journal of Infectious Diseases, 93*, 201–204. https://doi.org/10.1016/j.ijid.2020.02.033

Zhen, J., et al. (2020). Transmission of respiratory viruses when using public ground transport: A rapid review to inform public health recommendations during the COVID-19 pandemic. *South African Medical Journal, 6*. August 23, 2020). http://www.samj.org.za/index.php/samj/article/view/12943

Zhong, P., Guo, S., & Chen, T. (2020). Correlation between travellers departing from Wuhan before the spring festival and subsequent spread of COVID-19 to all provinces in China. *Journal of Travel Medicine, 27*(3). August 12, 2020). http://qianxi.baidu.com/

Zhuang, Z., et al. (2020). Preliminary estimation of the novel coronavirus disease (COVID-19) cases in Iran: A modelling analysis based on overseas cases and air travel data. *International Journal of Infectious Diseases, 94*, 29–31. https://doi.org/10.1016/j.ijid.2020.03.019