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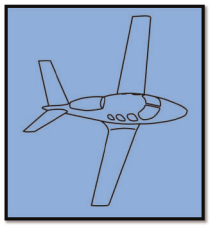

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COVID-19: Visualized Qualitative Aviation Research Themes

Chien-tsung Lu[1] and Huabo Sun[2]

[1]*Purdue University*
[2]*China Academy of Civil Aviation Science and Technology*

Abstract

The purpose of this study is to review pandemic-related publications that help the aviation industry cope with pandemic outbreaks like that of COVID-19. Published documents were searched and downloaded from academic libraries including Web of Science for a qualitative analysis. After the triangulation of publications for decisionmakers, and researchers, all important research clusters were visually generated based on the VOSviewer process. Some research clusters were further discussed for a thorough understanding of existing research perspectives. The result discovered that wearing a face mask and vaccination have been the two most effective means to counteract pandemic outbreaks. Additional findings were extracted from practitioners regarding the effectiveness of pandemic protocols and strategies.

Keywords: COVID-19, aviation emergency response, emergency preparedness, qualitative data visualization

I. Introduction

The outbreak of COVID-19 in early 2020 has caused substantial economic and financial damage to global systems, including the air transportation industry. COVID-19 has been announced by the World Health Organization (WHO) as a human-to-human communicable disease affecting public health globally (WHO, 2020). The damage has been nearly catastrophic as most airlines decided to ground a large portion of their fleets due to the lack of passengers as well as governmental restrictions on air travelers. Simultaneously, the massive reduction of passenger numbers directly affected airports' operation and revenue. Some of the impact resulted from an ineffective response to the disease spread throughout the world via components of air transportation systems. According to a report published in June 2020 by the International Air Transport Association (IATA), COVID-19 has had an impact far more severe than previous crises such as the global financial crisis (2007–2008) (IATA, 2018), 9/11 terrorist attack (2001), and SARS (2002–2003). A report published by the International Civil Aviation Organization (ICAO) in February 2021 also echoes that the COVID-19 pandemic outbreak has resulted in more than 60% (1,699 million) passenger volume reduction worldwide and financial loss close to USD$371B (IATA, 2020; ICAO, 2020, 2021). While the U.S. airline market had encountered financial loss close to USD$88B by February 2021, the Coronavirus Aid, Relief and Economic Security (CARES) Act of 2020 has enabled federal government

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to allocate USD$10B to eligible airports and USD$25B to airlines (with additional USD$25B for loans) to help the aviation industry survive (CARES, 2020) followed by the passage of the Coronavirus Response and Relief Supplemental Appropriation Act (CRRSAA, 2021).

While aviation stakeholders are working diligently to combat pandemic spread, the virus is evolving into variants. In other words, fighting the virus would need a long-term effort that aviation industry actors must learn from each other. It would be beneficial to the aviation community and decisionmakers if a list of leading research projects, guidelines, handbooks, programs, and the like can be prepared for a quick reference. It is also critical to identify specific topics and perspectives of existing research projects related to COVID-19, which show key focuses of the research projects and effective approaches/means currently recommended by governments, industries, member organizations, researchers, and experts.

II. Literature Reviews

A. Economic Impact Studies

COVID-19 has not only caused illnesses ranging widely but also imposed limitations on the global economy in different industries such as petroleum, stock markets, tourism, hotels, retailing, and regular societal commerce just to name a few. Economists like Hutt (2020) of the World Economic Forum noted that a slowdown of global economic growth was unavoidable, and the world would face a greater recession because of the COVID-19 outbreaks. Since airports serve as intersections of aviation systems, in 2011 Nishiura and Kamiya (2011) tested a fever screening process at an airport during a pandemic event at a specific international airport. Their study focused quantitatively on the feasibility of a screening method or strategy during the pandemic outbreak. In addition, in a Transportation Research Board (TRB) report, Smith and Greenberg (2017) conducted six case studies to measure the quality of airport emergency response plans and mitigation strategies related to two pandemic outbreaks—SARS in 2003 and Ebola in 2014. Chung (2015) suggested that less severe impact on airport economy could be achieved by a more efficient airport pandemic control plan and recommended a streamlined approach that would reduce economic impact by improving the overall effect of pandemic controls. Recently, Gold et al. (2019) applied evaluation-by-simulation experiments to evaluate the effectiveness of disease screening strategies at airports. All the aforementioned research projects have introduced preventive programs as well as recommendations for protection improvement.

B. Reports from Governmental Agencies

The WHO (2020), U.S. Department of Transportation (DoT), Federal Aviation Administration (FAA), Centers for Disease Control and Prevention (CDC), Airport Council International (ACI, 2020), Federal Emergency Management Administration, Transportation Security Administration (TSA), Government Accountability Office (GAO), and many others have worked persistently to develop preventive and recovery programs aiming to provide guidelines to the public as well as air operators to prevent further outspread of coronavirus. The pandemic prevention program is not new to the industry as TSA has collaborated with CDC to educate passengers, airlines, and airports through various workshops, forums, publications, and media channels that helped properly cope with communicable diseases such as SARS, Ebola, H1N1, swine flu, etc. In fact, according to FAA AC 150/5200-31C Chapter 6 Section 8, airports' emergency response plans shall include "emergency medical service (EMS), public health, environmental health, mental health, and mortuary services" (FAA, 2007, p. 80) and many scheduled airport emergence response drills or practices of emergency programs shall be conducted to respond to related undesired events. It is obvious that before COVID-19, most anticipated undesired events were related to aircraft incidents, accidents, or traditional onboard medical emergencies instead of epidemic or etiological threats. To reduce the risk of spreading quarantinable diseases via air travel, aviation stakeholders need to practice well to mitigate identified communicable diseases. A quick reference responding to pandemic outbreak is imperative.

C. Aviation Safety Management System (SMS)

Identifying potential hazards affecting aviation operations is the fundamental concept of contemporary risk management. The assurance of aviation safety has evolved from a reactive to a proactive and predictive fashion. The rationality of a proactive and predictive safety program is to detect hazards or threats and mitigate them before resulting in an accident. To be more proactive in promoting aviation safety, in 2000 the Safety Management Systems (SMS) was introduced by the FAA in the USA and has increasingly gained recognition from the industry. In 2010, the Airline Safety and Federal Aviation Administration Extension Act 2010 was passed to promote SMS implementation. On October 7, 2010, the FAA announced a new Notice of Proposed Rulemaking to collect comments from the industry regarding a mandatory airport SMS. As the aviation industry has anticipated, the new SMS regulation for Part 121 aviation service providers has been published as 14 CFR Part 5 (FAA, 2015).

D. Safety Risk Management

There are desires to understand how safety risk management (SRM) is used to decide the level of severity and likelihood of occurrence for decisionmakers. Since August

30, 2010, the FAA Order 5200.11 has started to mandate airport SRM noting that from June 1, 2011 all categories of hub airports, from June 1, 2012 all FAR 139 airports, from June 1, 2013 all towered airports, and from June 1, 2014 all NIPIAS airports must conduct SRM (FAA, 2010). Without doubt, epidemic-related risks should be no exception to this observation.

To be more proactive, the SRM process is one of the four fundamental pillars (policy, safety risk management, safety assurance, and safety promotion) of the SMS plan. SRM enables an organization to identify potential hazards, determine potential risks (likelihood and severity), and select and implement appropriate risk mitigation strategies through a systemic manner (FAA, 2010). It was in 2013 that TRB published *Infectious Disease in Airports and on Aircraft* aiming to provide guidelines for strategies that can be implemented to mitigate communicable diseases (TRB, 2013).

While the FAA has recommended maintaining a correspondent hazard database including communicable diseases for risk assessment and assurance, the list of related references is useful to stakeholders when encountering epidemic hazards. In the same vein, if an epidemic hazard collection tool is nonexistent, assessment could not be followed or calculated accurately. The result could mislead decisionmakers in program design or improvement. Equally important, visualized research focuses/themes could provide readers and researchers with a holistic view regarding critical perspectives or areas in counteracting pandemics and communicable diseases.

E. Research Questions

1. What pandemic response publications are available to the aviation community?
2. What are the specific research topics and perspectives related to COVID-19?
3. What approaches were studied to prevent COVID-19 outbreak or transmission?
4. What programs or strategies were most successful for the COVID-19 response?

III. Research Approaches and Methodology

To answer Question 1, the work reported in this paper began with a search of academic databases that contain published papers, manuals, and guidelines from which the researcher was able to download. For Questions 2 and 3, some paired keywords for publication searches were the following: (1) “COVID-19” and “Aviation Industry,” (2) “COVID-19” and “Air Transportation,” (3) “COVID-19” and “Aviation,” (4) “Coronavirus” and “Aviation Industry,” (5) “Coronavirus” and “Air Transportation,” (6) “Coronavirus” and “Aviation,” and (7) “COVID-19” and “Controls.” Accordingly, seven qualitative datasets were downloaded.

Downloaded documents were categorized for a quick reference, while for Questions 2 and 3, Web of Science was used to download publications in full-record format. These downloaded documents were then converted into .txt format for the VOSviewer process. VOSviewer is a program that uses artificial intelligence (AI) to review, analyze, and extract qualitative themes, highlights, or clusters available to researchers for a further interpretation (VOSviewer, n.d.). VOSviewer enables a researcher to visually discover themes or clusters from a large amount of qualitative documentation providing a general landscape of interconnection among significant clusters/themes based on frequencies of appearances.

A. Research Approach

The study started with a search of published literature to identify government manuals, guidelines, regulations, and the like related to etiological trace and controls, health screening, hygiene, and infection protection in the global aviation system. In addition, manuals from government, member organizations, airports, airlines, consultation companies (CDC, WHO, ICAO, IATA, U.S. DoT, EASA, FAA, TSA, ACI, ALPA, GAO, TRB, etc.), and many others were categorized as a reference list for future emergency response program design and development. Since aviation is global in nature, international sources from foreign representative nations were also collected. The literature triangulation process has been indispensable because the refined lessons learned or successful experiences from the global aviation industry are of great

Table 1
Arranged tasks of the project.

Task no.	Required tasks	Methodological approach
1	Reference based on existing vetted materials (Q.1)	Documentation review and content/meta-analysis
2	Converted .txt files and documents (Q.2 and Q.3)	Searching Web of Science
3	Visualized decisionmaking aids: themes, highlights, and clusters (Q.2 and Q.3)	VOSviewer and meta-analysis
4	Practitioner’s feedback concerning best practices (Q.4)	Convenience sampling, interview, and data collection

interest to air operators as well as decisionmakers. Table 1 shows the tasks of this research project.

B. Data Collection Exercise

To ensure a detailed analytical insight, the researcher applied a mix of documentation reviews, qualitative search using keywords to generate a database including papers, best practices, and guidelines ready for the VOSviewer process. The researcher executed practical ideas and research initiatives using the Action Research (AR) concept to conduct a "look–think–act" process in order to form practical knowledge for the needed industry (Chalmers & Colvin, 2005; Lu et al., 2011; Springer, 1996). As the AR concept is a scientific approach for evident discovery, the researcher experienced first-hand challenges, process cognition, and available knowledge, and implemented selected strategies. A flowchart provided in Figure 1 is the AR procedure modified for this project.

IV. Findings

A. What Pandemic Response Publications Are Available to the Aviation Community?

The list of important references is provided in the Appendix including governments, member organizations, airports, and other publications (airlines, journal articles, and consultation companies). This final list was extracted and triangulated from the original 572 aviation-related publications (six keywords) and can be ready for further studies and provide researchers, aviation safety specialists, and stakeholders with a quick reference list for counteracting pandemic risks. During the study of this research question, AR's "look–think–act" process was considered and implemented to validate the list. All the keyword search results were compared, condensed, and prepared for VOSviewer's qualitative visualization process for Question 2. There were 229 highly cited papers selected to answer Question 3.

B. What Are the Specific Research Topics and Perspectives Related to COVID-19?

After the verification of the reference list, identified datasets were submitted to VOSviewer for a pictorial analysis. VOSviewer then generated visual interconnection maps and provided the following clustered research themes: COVID, pandemic, airline, passenger, country, and impact (see Figure 2). According to Figure 2, a further analysis showed that researchers were concerned about the impact of COVID-19 on both international and domestic airline passenger markets. The impact of pandemic outbreak on airports was also significantly discussed.

The overall interconnection map is shown in Figure 3 including categorized COVID-related clusters (sector/India, time/year, passenger, case/number/data/country; aviation sector, impact and India; airline industry, research papers/articles; and pandemic study, airport, passenger, and aviation industry). The setting of VOSviewer was based on "20" occurrences and "30" most relevant terms in this COVID-centered study. The density map is shown in Figure 4 reflecting the clustered findings of Figure 3.

Another important clustered finding was that China, India, and Malaysia were three frequently mentioned countries. The clusters of "flight," "passenger," "case," "opportunity," and "risk" were most studied (see Figures 5 and 6). It is unique that "student" cluster was a standalone research theme and of course there were many known theories related to it during the unusual pandemic time.

C. What Approaches Were Studied to Prevent COVID-19 Outbreak or Transmission?

According to Figures 7 and 8, there were four important approaches (as clusters shown in the interconnection map) studied to control COVID-19 outbreak or transmission, namely: virus transmission, evidence-based intervention, patient treatment and mortality, and symptoms and therapy.

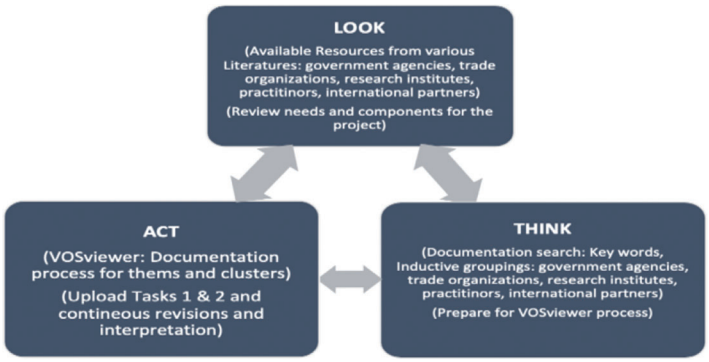

Figure 1. Action Research execution flowchart.

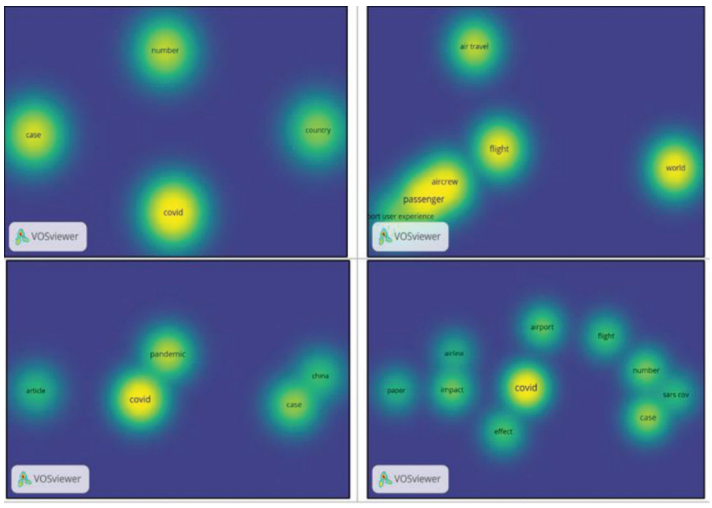

Figure 2. Individual density maps—impact of COVID-19 upon aviation targets.

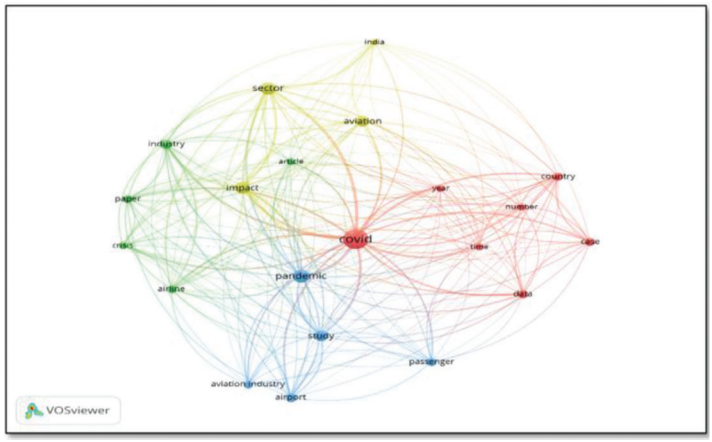

Figure 3. Overall interconnection map—COVID-19 impact upon aviation targets.

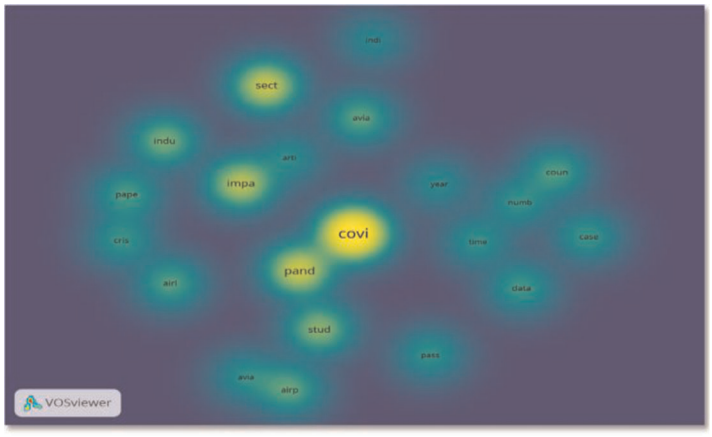

Figure 4. Overall density map—COVID-19 impact upon aviation targets.

While other subclusters were also critically cited, such as convalescent plasma, mask, child, and randomized controlled trial, this research revealed important approaches to control disease including personal protective equipment (PPE) and mask (see Figure 9). Other clusters were: vaccine development, elder adults and healthcare workers, anxiety and mental health, pathogen and human transmission, prevention and intervention, emergency response and modeling.

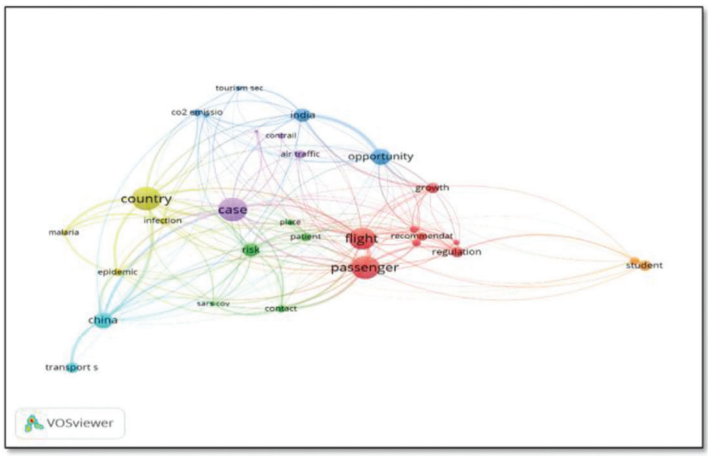

Figure 5. Overall interconnection map—aviation clusters.

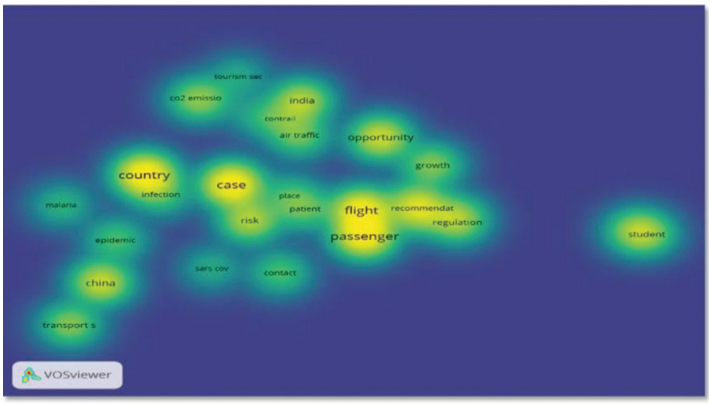

Figure 6. Overall density map—aviation cluster.

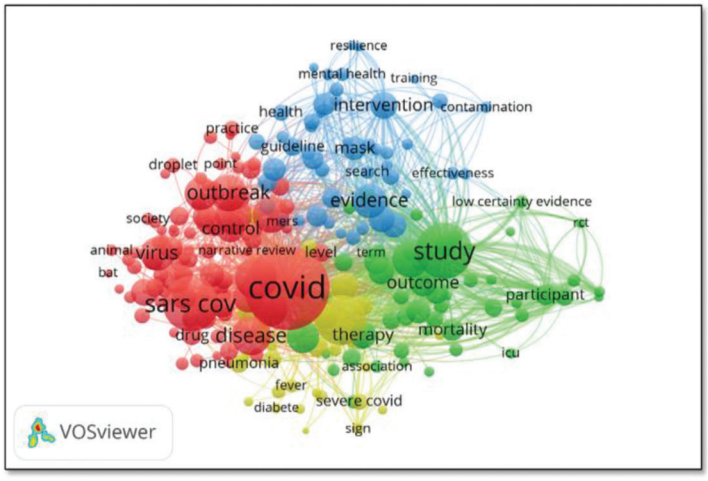

Figure 7. Overall interconnection map—COVID-19 controls.

Not surprisingly, further analyses of *treatment*, *vaccine*, *efficacy*, and *effect* all show a strong connection to patients and disease controls from selected research projects (see Figure 10). This generalized observation does echo the fact that vaccine development has been one of the best solutions to combat COVID-19 and restore air transportation systems.

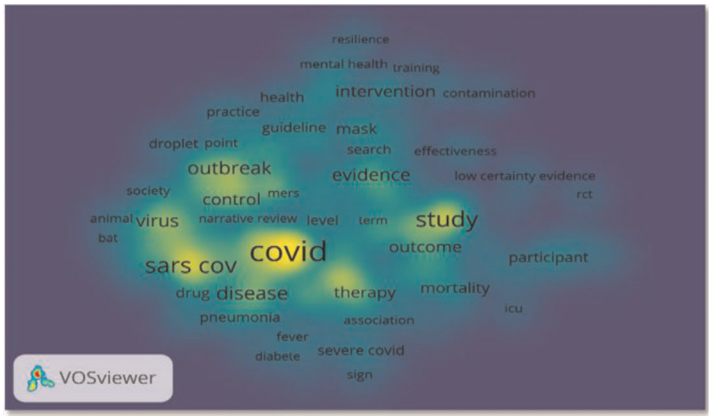

Figure 8. Overall density map—COVID-19 controls.

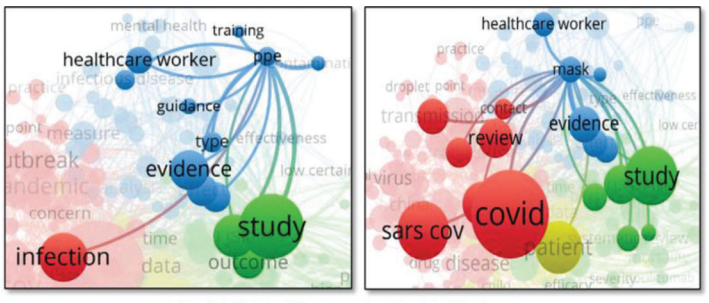

Figure 9. COVID-19 controls—PPE and mask.

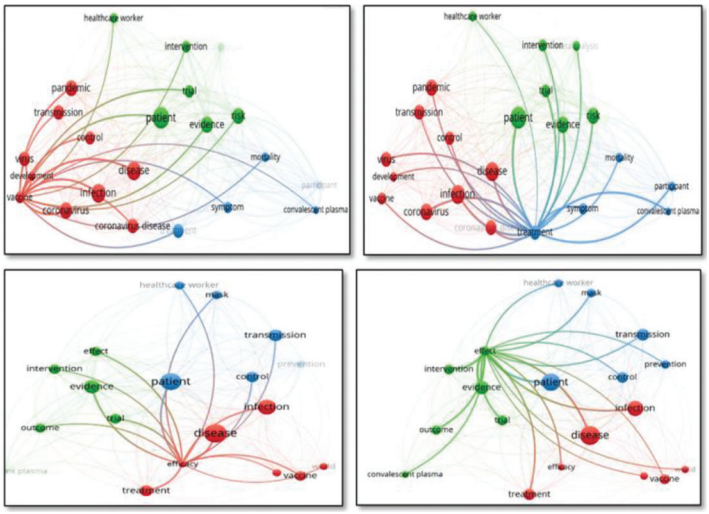

Figure 10. Selected COVID-19 controls—treatment, vaccine, efficacy, and effect.

D. What Programs or Strategies Were Most Successful for the COVID-19 Response?

According to the feedbacks from voluntary participants, airline pilots, and managers, there were prevailing strategies or protocols recognized to be effective practices.

For cockpit crew members, the following protocols showed effectiveness:

- Wearing face masks/shields during operations.
- Mandatory vaccination for international travels unless a vaccination contradiction report was provided.
- Strict cleaning procedures for crew members.
- Published quarantine process upon arrival into or back from another country.
- Authorized access to the flight deck and training facilities.
- Self-declaration of abnormal symptoms or PCR test report.
- Temperature screening.

- Continuous COVID-19 health monitoring training/education or policy change.

For aircraft, replacing cabin air filters frequently, installation of HEPA air filters, blocking middle seats, and reducing load factor for a reasonable onboard social distancing, cancellation of onboard food service, and cabin disinfection and cleaning.

For passengers, besides wearing face masks, they were recommended to use self-service robots, kiosks, or APP (such as "Verifly") for e-tickets, boarding passes, travel documents, as well as using luggage self-check-in posts. Facial recognition (Global Entry, CLEAR, or the like) for security clearance or contactless procedures were highly advocated. Vaccination record and PCR negative reports were required for international travelers. Onboard pandemic awareness training videos played a significant role for passenger health and safety as did providing free hand sanitizer wipes.

While airlines suffered from unprecedented drops in passenger volume and revenue during COVID-19, to survive, some actions were taken, including:

- Parking aircraft and leasing contract negotiations.
- Temporary furloughing unneeded manpower, workload reduction, and awarding early retirement packages.
- Seeking governmental aids.
- Converting passenger aircraft for cargo/freight service.
- Optimization of flight scheduling and needed staff.
- Imposing mileage usage restrictions.
- Dynamic operations of both hub-and-spoke and point-to-point services.
- Negotiating waiver of fees or lower rents or both.
- Improving social media presence.
- Fuel hedging and global economic forecast.
- Emission-reduction research, innovation, and credit for post-pandemic recovery.

V. Conclusion

The result of this study created a reference list for aviation stakeholders and decisionmakers counteracting the spread of communicable diseases not only in the USA but also operators worldwide. This list helps aviation practitioners proactively prevent business interruption due to pandemic outbreak as well as to generate practical recovery plans. The researcher applied the AR concept and VOSviewer process to develop interconnection maps and clustered themes based on public publications in aviation fields. The VOSviewer categorized collected documents related to pandemic management and transformed them into visual landscapes that help decisionmakers and researchers to quickly identify perspectives that had been studied. Following the inductive study, effective strategies to cope with the unusual global pandemic were provided based on airline practitioners' feedbacks. While the airline business is slowly moving toward recovery from substantial impact inflicted by COVID-19, it also creates an opportunity for the industry to learn unique lessons and prepare for future prospects.

A. Future Study

The reference list was extracted from 572 publications in relation to both "aviation" and "COVID-19" and from Web of Science. While Web of Science is comprehensive, it only collects science-indexed publications such EI, SCI, SSCI, etc. Nonindexed research papers or articles were not reviewed by the authors, which yields a follow-up study. Even though there are developing COVID-19 variants, the collected publications in this paper act as a foundation and remain valid and useful regardless of the increase in the amount of newer publications. A similar situation also applied to 229 "most cited" indexed papers involving keywords "COVID-19" and "Controls." While the COVID-19 variants are developing, a continuous monitoring is recommended. A future study should be continued to address innovative strategies or technologies to mitigate communicable diseases.

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Author Background

Chien-tsung Lu is an Associate Professor at Purdue University. Huabo Sun is a senior research fellow at the Institute of Aviation Safety, China Academy of Civil Aviation Science and Technology in Beijing.

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Appendix

Pandemic Response Publications. A Reference List for the Aviation Community

Airports

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