United States Government Accountability Office

Report to Congressional Committees

July 2022

AIR TRAVEL AND COMMUNICABLE DISEASES

Federal Leadership Needed to Advance Research

Accessible Version

GAO-22-104579

GAO Highlight

Highlights of GAO-22-104579, a report to congressional committees

July 2022

AIR TRAVEL AND COMMUNICABLE DISEASES

Federal Leadership Needed to Advance Research

Why GAO Did This Study

The COVID-19 pandemic has intensified ongoing concerns about air travel's role in spreading disease and raised questions about the safety of passengers and crew. Research that could provide quality information on communicable diseases in air travel can help to protect public health.

The CARES Act includes a provision for GAO to monitor and report on federal efforts related to the COVID-19 pandemic. GAO was also asked to review research on disease transmission in air travel. This report examines: (1) the status of research on communicable diseases in air travel, including stakeholders' views on additional needed research and challenges to conducting it, and (2) the extent to which FAA and other federal agencies are advancing such research.

To conduct this work, GAO interviewed stakeholders, including federal officials, researchers, and aviation industry and union representatives. GAO also reviewed academic literature and agency documents, including research plans, as well as key considerations for interagency collaboration.

What GAO Recommends

Congress should consider directing FAA to develop and implement a strategy to identify and advance needed research on communicable diseases in air travel, in coordination with appropriate federal agencies—such as DHS and HHS—and external partners.

View GAO-22-104579. For more information, contact Heather Krause at (202) 512-2834 or krauseh@gao.gov.

What GAO Found

GAO identified research conducted on communicable diseases in air travel in several areas. For example, research has examined how air moves in aircraft and studied the effect of different airline operations—such as boarding aircraft from back to front—on the risk of disease exposure. However, stakeholders GAO interviewed described the need for more research involving real-world situations and human behavior. Additional research could inform the development of evidence-based mitigation measures, policy, and regulations to protect public health. Stakeholders cited several challenges, particularly the lack of federal leadership to facilitate interdisciplinary research and address gaps, to conducting research on communicable diseases in air travel. Stakeholders said researchers' inability to access aircraft, airports, or data also poses challenges to performing needed research.

Examples of Conditions or Behaviors That May Affect Disease Transmission on an Airplane

Source: GAO illustration of information provided by stakeholders. | GAO-22-104579

Several agencies have focused on those research areas most relevant to their priorities and mission. Such agencies include the Department of Health and Human Services (HHS), the Department of Transportation's Federal Aviation Administration (FAA), and the Department of Homeland Security (DHS). None of these agencies have undertaken efforts to advance needed research on communicable diseases in air travel more broadly. Officials with each of these agencies said a more coordinated federal approach to identify and advance relevant research could generate valuable information and inform policy development and guidance. In addition, bringing various federal agencies' assets to bear could link researchers with aviation stakeholders across areas of expertise, provide clearer access to federal funding for research, and help identify needed research across different disciplines.

While FAA acknowledges that it has broad authority to conduct and sponsor research on communicable diseases in air travel, the agency has historically maintained that this work lies outside its core responsibility for aviation safety. Yet, FAA has prior experience conducting and supporting such research, as well as strong aviation industry ties critical to advancing needed research. In particular, FAA has undertaken related research in the past—usually in response to statutory mandates—including work on disease transmission in aircraft cabins. Moreover, leading the development of a coordinated strategy would be consistent with FAA's efforts to develop a national aviation-preparedness plan, in coordination with DHS and HHS, as GAO recommended. Such a strategy would

help focus research efforts to better inform the development of policies and requirements to protect the health of passengers and crew.

Contents

Abbreviations

ACER	National Center of Excellence for Airliner Cabin Environment Research
ACERite	National Air Transportation Center of Excellence for Research in the Intermodal Transport Environment
AMC	Air Mobility Command
CAMI	Civil Aerospace Medical Institute
DHS	Department of Homeland Security
DOT	Department of Transportation
CDC	Centers for Disease Control and Prevention
DGMQ	Division of Global Migration and Quarantine
FAA	Federal Aviation Administration
HEPA	high efficiency particulate air
HHS	Department of Health and Human Services
MERS	Middle East Respiratory Syndrome
MOU	memorandum of understanding
NASA	National Aeronautics and Space Administration
NIAID	National Institute of Allergy and Infectious Diseases
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
R&D	research and development
REDAC	Research, Engineering, and Development Advisory Committee
S&T	Science and Technology Directorate
SARS	severe acute respiratory syndrome
TRANSCOM	U.S. Transportation Command
TSA	Transportation Security Administration

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July 28, 2022

Congressional Committees

As of June 2022, nearly 85 million cases of COVID-19 had been reported in the United States, resulting in over a million deaths.[1] COVID-19 is only the latest disease to raise concerns about communicable diseases in air travel, including both health risks to passengers and the unique role that air travel plays in the spread of diseases globally.[2] Since 2002, several major public health epidemic threats have had global ramifications, including the severe acute respiratory syndrome (SARS) in 2003, the H1N1 influenza pandemic in 2009, the Middle East Respiratory Syndrome (MERS) in 2012, and Ebola in 2014.

These disease outbreaks have led to calls for the Department of Transportation (DOT) and the Federal Aviation Administration (FAA), in cooperation with other relevant federal agencies, to be more involved in preparing for and responding to the threat posed by communicable diseases in air travel. Throughout the COVID-19 pandemic, discussion has continued over governmental policies and requirements addressing travel restrictions, masking, testing, vaccinations, aircraft occupancy restrictions, and the ventilation of aircraft, among other areas affecting both air travel and public health. While research could improve the quality of information used to inform the development of such policies and requirements, we have previously reported that FAA has sponsored

[1]Data on COVID-19 cases in the U.S. are based on aggregate case reporting to the Centers for Disease Control and Prevention (CDC) and include probable and confirmed cases as reported by states and jurisdictions. CDC COVID-19 counts are subject to change due to delays or updates in reported data from states and jurisdictions. According to CDC, the actual number of COVID-19 cases is unknown for a variety of reasons, including that people who have been infected may have not been tested or may have not sought medical care. See CDC, "COVID Data Tracker: Trends in Number of COVID-19 Cases and Deaths in the US reported to CDC, by State/Territory," accessed June 7, 2022, https://covid.cdc.gov/covid-data-tracker/#trends_dailycases.

[2]For more information, see GAO, *Air Travel and Communicable Diseases: Comprehensive Federal Plan Needed for U.S. Aviation System's Preparedness,* GAO-16-127 (Washington, D.C.: Dec. 16, 2015).

limited federal research into disease transmission onboard aircraft and in airports.[3]

The CARES Act includes a provision for us to report on our ongoing monitoring and oversight efforts related to the COVID-19 pandemic.[4] This report is a part of that body of work. We were also asked to review the status of research on disease transmission via air travel. This report examines:

- the status of research on communicable diseases in air travel, including stakeholders' views on additional needed research and the challenges to conducting it, and
- the extent to which FAA and other federal agencies are advancing such research.

For the purposes of our review, air travel refers to the movement of passengers and crew through airports, onto and off aircraft, and in flight. Our scope does not include air travel's role in facilitating the spread of diseases from one part of the world to another, or between different modes of transportation (e.g., airport to bus or transit system).

To examine the status of research on communicable diseases in air travel and challenges to conducting this research, we reviewed academic literature and prior GAO work, monitored relevant news and publications, and interviewed researchers and other stakeholders. Our nongeneralizable selection of stakeholders included researchers, union and industry representatives, and federal agency officials. We identified

[3]In June 2020, we testified to Congress regarding the status of FAA's research efforts. For more information, see GAO, *Air Travel and Communicable Diseases: Status of Research Efforts and Action Still Needed to Develop Federal Preparedness Plan,* GAO-20-655T (Washington, D.C.: June 23, 2020). For more information about how quality information is needed for federal management, see GAO, *Standards for Internal Control in the Federal Government,* GAO-14-704G (Washington, D.C.: Sept. 10, 2014).

[4]Pub. L. No. 116-136, § 19010(b), 134 Stat. 281, 579-80 (2020). We regularly issue government-wide reports on the federal response to COVID-19. For the latest report, see GAO, *COVID-19: Current and Future Federal Preparedness Requires Fixes to Improve Health Data and Address Improper Payments,* GAO-22-105397 (Washington, D.C.: Apr. 27, 2022).

these stakeholders to interview through open-source research, our literature search, and through interviews.[5]

We conducted interviews with 17 researchers across seven issue areas, including ventilation and filtration, human behavior, and epidemiology.[6] In addition to researchers, we interviewed representatives from unions for flight attendants and pilots, as well as consumer advocates. We also gathered aviation industry views from Airlines for America, Airports Council International North America, and Delta Air Lines. We spoke to federal agency officials at the FAA Office of Aerospace Medicine's Civil Aerospace Medical Institute (CAMI), the Centers for Disease Control and Prevention's (CDC) National Institute for Occupational Safety and Health (NIOSH), and the Department of Homeland Security's (DHS) Science and Technology Directorate, among others.

To examine the extent to which FAA and other federal agencies are advancing research on communicable diseases in air travel, we reviewed agency reports and documents, including research plans for FAA and selected agencies within DHS and the Department of Health and Human Services (HHS). In this context, advancing research would include providing sustained support to identify and further needed research. We also interviewed officials from the agencies noted above, as well as officials with CDC's Division of Global Migration and Quarantine and DHS's Transportation Security Administration (TSA). We identified these agencies based on our initial meeting with FAA and internal discussions with GAO stakeholders.

In addition, we have identified federal collaborative efforts for research in our prior work, including a review assessing FAA's collaboration with

[5]Our initial literature review identified peer-reviewed studies published in 2020 and included work conducted in a variety of research areas. For the purposes of this report, we have focused our findings on those research areas that are most salient to COVID-19. To better understand how the volume of research published on communicable diseases in air travel has changed over time, we performed two additional citation-count searches in Scopus, for academic journal articles and conference papers published from January 2011 through July 2021. We continued to monitor research publications through March 2022 and contacted researchers and agency officials to stay abreast of relevant research. See appendix I for more information about our literature review. See appendix II for additional information about research on communicable diseases in air travel, including selected citations.

[6]More information about these issue areas and researchers is included in appendix I.

NASA.[7] We reviewed key considerations for interagency collaboration to identify mechanisms and associated leading practices for effective collaboration, which is defined broadly as any joint activity that is intended to produce more public value than could be produced when agencies act alone.[8] See appendix I for additional detail on our scope and methodology.

We conducted this performance audit from October 2020 to July 2022 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Communicable Diseases in Air Travel

Air travel is unique with regard to the transmission of communicable disease, among travelers and in communities.[9] A 2013 report prepared by

[7]GAO, *Aviation Research and Development: FAA Could Improve How It Develops Its Portfolio and Reports Its Activities,* GAO-17-372 (Washington, D.C.: Apr. 24, 2017).

[8]For more information about collaborative mechanisms and associated leading practices, see GAO, *Managing for Results: Key Considerations for Implementing Interagency Collaborative Mechanisms,* GAO-12-1022 (Washington, D.C.: Sept. 27, 2012). For the purposes of a collaborative strategy for research on communicable diseases in air travel, relevant features include identifying leadership, clarifying roles and responsibilities, determining resources needed, and documenting relevant agreements. More information about these practices is provided in appendix I.

[9]While outside the scope of our work, a 2021 study found a strong relationship between cases of COVID-19 and air passenger volume, using real flight data to measure air travel's impact on the COVID-19 pandemic. For more information, see Lu Dai, Ivan Tereshchenko, Mark Hansen, "Quantifying the Impact of Air Travel on Growth of COVID-19 Pandemic in the United States," presented at the Fourteenth USA/Europe Air Traffic Management Research and Development Seminar (ATM2021).

the Airport Cooperative Research Council identified transmission risks specific to air travel, including:[10]

- **Aircraft cabin.** Within the aircraft cabin, passengers and crew from different geographic regions can be in close proximity for long durations with limited cleaning between uses through any given day. Opportunities for disease transmission may occur not only while directly adjacent to an infectious person during flight, but also during boarding or disembarking as the passenger traverses a contaminated area or touches a contaminated surface. Aircraft ventilation systems—particularly high efficiency particulate air (HEPA) systems—can mitigate some of these risks, if they are in operation.[11]
- **Airports.** Airports differ from other settings such as schools, malls, and movie theaters in the scale and nature of interactions. At airports, a large number of individuals from geographically diverse regions with differing population immunity and endemic diseases all interact with airline and airport operations staff and with each other.[12]
- **Transmission routes.** There are three general routes of transmission for communicable diseases in air travel: (1) through aerosols that remain airborne for long periods and can be inhaled, (2) through large droplets that may be ingested or settle on surfaces, or (3) through direct contact with secretions, bodily fluids, or contaminated surfaces.[13]

[10]This report, which focused on the mitigation of infectious disease in airports and on aircraft, was prepared by the Airport Cooperative Research Council (ACRP) of the Transportation Research Board with support from FAA. For more information, see National Academies of Sciences, Engineering, and Medicine, *Infectious Disease Mitigation in Airports and on Aircraft,* https://doi.org/10.17226/22512 (Washington, D.C.: 2013).

[11]HEPA filtration can remove 99.9 percent of virus and bacteria particulates and exchange cabin air every 2 to 3 minutes, according to Boeing, which provides information about aircraft ventilation on its website. See Boeing, “Travel Confidently with Boeing: Cabin Air,” accessed January 21, 2022, https://www.boeing.com/confident-travel/cabin-air.html. Not all aircraft have HEPA filtration.

[12]In statute and regulation, airlines are generally referred to as “air carriers”; we refer to them as “airlines” for the purposes of this report.

[13]Some infectious diseases are contagious (or communicable), that is, spread from one person to another. Other infectious diseases can be spread by germs carried in air, water, food, or soil. They can also be spread by vectors (like biting insects) or by animals. For purposes of this report, we are focused on those communicable diseases that might be spread from person to person during travel.

During the COVID-19 pandemic, understanding of how the disease is transmitted has improved, yet some basic information remains unknown or has changed as the virus continues to evolve and new variants emerge.[14] For example, SARS-CoV-2, the novel coronavirus that causes COVID-19, is now known to spread when an infected person breathes out droplets or aerosols, which may be inhaled or spread through contact with the eyes, nose, or mouth. The infectiousness of the virus has changed over time with the emergence of variants, such as Delta and Omicron. Moreover, vaccine effectiveness can vary in protecting individuals against different variants.[15] Questions about the risk factors associated with the transmission of COVID-19 also remain.

Throughout the COVID-19 pandemic, airports and airlines have taken different approaches to protecting passengers.[16] For example, some airlines independently added additional cleaning protocols for their aircraft, kept middle seats empty, or required masking prior to the federal mandates. Mitigation practices differed in other areas as well, such as whether airlines operated aircraft ventilation systems during boarding and deplaning, as has been recommended by the Airport Cooperative Research Program and others to improve cabin air quality and reduce the spread of pathogens. Individual airports also took steps including changes in their cleaning regimes or calling for social distancing to minimize the spread of the virus.[17] (See fig. 1.)

[14]For example, the infectivity and infectiousness of SARS-CoV-2 is not fully known and may likely vary by individual. Infectivity is the ability of the disease agent to enter, survive, and multiply in the host. Infectiousness indicates the relative ease with which a disease is transmitted to other hosts. Officials with DHS also pointed to the need for additional research on basic characteristics of the virus, as well as the number and size of particles emitted by infected people during routine activities such as coughing, breathing, and speaking.

[15]For more information about Coronavirus variants, see Kathy Katella, "Omicron, Delta, Alpha, and More: What to Know about the Coronavirus Variants," *Yale Medicine*, accessed February 28, 2022, https://www.yalemedicine.org/news/covid-19-variants-of-concern-omicron.

[16]During the COVID-19 pandemic, CDC issued some orders, such as those limiting entry for certain persons, testing requirements for those boarding a flight to the United States and vaccination requirements for noncitizens who are non-immigrants seeking to enter the United States by air travel. As of July 2022, some of these orders have been extended, amended, replaced, terminated, or vacated by a federal district court.

[17]Because airports are often owned by state, local, territorial, tribal, or multi-jurisdictional public entities, mitigations may vary by locality.

Figure 1: Example of Airport Covid-19 Mitigation

Source: Seattle-Tacoma International Airport. | GAO-22-104579

As understanding of COVID-19 has evolved, federal, state, and local policies and responses also have changed. For example, initial guidance on COVID-19 from CDC and others focused on addressing the risk from contaminated surfaces and droplet transmission. Attention later turned to mitigating the spread of aerosols, when it became clearer that COVID-19 is primarily an airborne, respiratory disease. In response, persons in U.S. airports had, up until April 18, 2022, been subject to federal mask mandates, as discussed below.[18]

[18]This applied to persons in airports subject to the jurisdiction of the United States. On April 18, 2022, a federal district court order vacated the CDC's mask mandate, finding that the CDC's mask mandate exceeds CDC's statutory authority and violates the procedures required for agency rulemaking under the Administrative Procedure Act. The case was remanded to the CDC for further proceedings consistent with the judicial order, *Health Freedom Defense Fund, Inc., et al v. Biden et al*, 8:21-cv-1693-KKM-AEP (April 18, 2022). On April 20, 2022, the Department of Justice filed a notice of appeal of the federal district court order.

Federal Roles and Research Priorities

A number of federal agencies have roles and responsibilities in preparing for communicable disease threats in the aviation system, assessing them, and responding to them. The missions and legal authorities of the agencies in our review guide these roles and responsibilities.[19] HHS and DHS focus on protecting the nation from domestic and foreign health, safety, and security threats and protecting our borders at ports of entry, including airports, from threats from abroad.[20] Within DOT, FAA is generally responsible for aviation safety. More specifically:

- Within HHS, CDC aims to protect the nation's health—together with local health departments—and generally addresses disease surveillance and infection control. Within CDC, the Division of Global Migration and Quarantine focuses on the public health risks of rapid global travel, because diseases and outbreaks can quickly cross international borders. Also within CDC, NIOSH studies occupational safety and health.

[19]Although not included in our review, the Occupational Safety and Health Administration (OSHA) within the Department of Labor aims to assure safe and healthful conditions for workers by setting and enforcing standards and by providing training, outreach, education, compliance, and assistance. OSHA standards are not applicable to working conditions for aircraft cabin crewmembers onboard an aircraft while it is in operation, with the exception of OSHA's standards on hazard communication, blood-borne pathogens exposure, and occupational noise exposure, as recognized in a memorandum of understanding (MOU) between OSHA and FAA. An aircraft is considered by FAA to be "in operation" from the time it is first boarded by a crewmember, in preparation for a flight, to the time the last crewmember leaves the aircraft after completion of that flight. See *Memorandum Of Understanding Between The Federal Aviation Administration U.S. Department Of Transportation And The Occupational Safety And Health Administration U.S. Department Of Labor,* August 26, 2014.

[20]Under section 361 of the Public Health Service Act, as amended (codified as amended at 42 U.S.C. § 264), HHS is authorized to make and enforce regulations to prevent the introduction, transmission, or spread of communicable diseases from foreign countries into the United States or possessions and among states and possessions. The authority for carrying out these functions on a daily basis has been delegated to CDC, an agency in HHS. With respect to DHS, the National Defense Authorization Act for Fiscal Year 2022, enacted in December 2021, requires the Secretary of DHS, acting through TSA, in coordination with the Chief Medical Officer of DHS, and in consultation with appropriate federal departments and agencies, including HHS, CDC, DOT, the Department of Labor, appropriate interagency task forces, and certain specified types of public and private stakeholders, to develop a transportation security preparedness plan to address the event of a communicable disease outbreak. Pub. L. No. 117-81, § 6412, 135 Stat. 1541, 2409 (2021).

- Within DHS, Customs and Border Patrol aims to safeguard the nation's borders and TSA is responsible for securing the nation's transportation system. During the COVID-19 pandemic, for example, TSA issued several security directives to address COVID-19 in travel and to implement a federal executive order mask mandate and enforce a related CDC order.[21]
- Within DOT, FAA and the Office of the Secretary of Transportation are generally responsible for aviation safety and for aviation economic matters and consumer protection, respectively. In these roles, FAA and DOT's Office of the Secretary have promulgated rules addressing public safety and health issues, such as the use of seatbelts and smoking aboard U.S.-regulated aircraft. DOT and FAA have strong ties to key aviation stakeholders, such as international civil aviation organizations. They also have oversight responsibilities for airlines, airports, and other members of the aviation industry. For example, in response to COVID-19, FAA and DOT's Office of the Secretary collaborated with interagency partners on the development of international and domestic guidance for airlines, airports, and others to mitigate the public health risks of COVID-19.[22] To help improve the U.S. aviation sector's preparedness for future communicable disease threats, DOT has recently agreed to work closely with DHS and HHS to develop a national aviation-preparedness plan, in accordance with international standards and as we have recommended since 2015.[23]

[21]During the COVID-19 pandemic, TSA has issued various security directives, among other things, to implement Executive Order 13998, *Promoting COVID-19 Safety in Domestic and International Travel,* and CDC's related Order, *Requirement for Persons to Wear Masks While on Conveyances and at Transportation Hubs.* Executive Order 13998, 86 Fed. Reg. 7205 (Jan. 26, 2021); CDC, *Requirement for Persons to Wear Masks While on Conveyances and at Transportation Hubs*, 86 Fed. Reg. 8025 (Feb. 3, 2021). TSA security directives include, for example, Transportation Security Administration, *Mask Requirements for Airports within the United States*, SD 1542-21-01C (Dec. 17, 2021); Transportation Security Administration, *Mask Requirements for Aircraft Operators Regulated under 49 C.F.R. 15444.101*, SD 1544-21-02C (Dec. 17, 2021).

[22]For example, in December 2020, DOT, DHS, and HHS jointly issued updated guidance to airports and airlines for implementing measures to mitigate the public health risks associated with COVID-19. See *Runway to Recovery: The United States Framework for Airlines and Airports to Mitigate the Public Health Risks of Coronavirus, Version 1.1,* Guidance Jointly Issued by the U.S. Departments of Transportation, Homeland Security, and Health and Human Services (Washington, D.C.: December 2020).

[23]For more information, see GAO, *Air Travel and Communicable Diseases: Comprehensive Federal Plan Needed for U.S. Aviation System's Preparedness,* GAO-16-127 (Washington, D.C.: Dec. 16, 2015), and GAO, *Covid-19: Opportunities to Improve Federal Response and Recovery Efforts,* GAO-20-625 (Washington, D.C.: June 25, 2020).

Each agency also supports research as related to its mission, as shown in table 1.

Table 1: Agency Research Priorities Related to Communicable Diseases in Air Travel

Selected Agency	Research Priorities
CDC's National Institute for Occupational Safety and Health (NIOSH)	NIOSH's mission is to develop new knowledge in the field of occupational safety and health and to transfer that knowledge into practice. NIOSH research priorities cross worker populations and sectors, such as agriculture and transportation, and include workers in air travel settings.
CDC's Division of Global Migration and Quarantine (DGMQ)	DGMQ has a public health response role that is supported through public health surveillance, contact tracing, and outbreak investigations related to the aviation sector. While it does not have a formal research role, according to officials, the findings of its investigations may contribute to research by others.
DHS's Science and Technology Directorate (S&T)	S&T conducts basic and applied research, development, testing, and evaluation activities. It coordinates its R&D strategy with other branches of DHS, including the Transportation Security Administration. Research priorities have traditionally been focused on improving security—including improvement within the nation's transportation systems, such as checkpoint automation.
Federal Aviation Administration (FAA)	FAA's research priorities are focused on commercial and general aviation flight safety. These priorities are guided by five goals: improving operations, accelerating the use of new technologies, capitalizing infrastructure, improving the operation of the human component of the system, and improving modeling capabilities and analysis.

Source: GAO analysis of information from the Centers for Disease Control and Prevention (CDC), the Department of Homeland Security (DHS), and the Federal Aviation Administration (FAA). | GAO-22-104579

FAA supports and coordinates a range of research activities for the civil aviation system—both through in-house research and in collaboration with other entities.[24] Support for external research can include conducting research with or making grants to other government agencies, universities, and private sector organizations.[25] Within the agency, research is conducted primarily by the:

[24]According to FAA officials, in addition to specific statutory mandates, the FAA relies primarily on statutory authorities in 49 U.S.C. Chapter 445 to conduct a wide range of aviation safety-related research and development. For example, pursuant to 49 U.S.C. § 44513, the FAA may make grants to institutions of higher education that are members of FAA regional centers of air transportation excellence for "aviation safety and security" and "other aviation issues related to developing and maintaining a safe and efficient air transportation system." 49 U.S.C. § 44513(b)(1)(A)(iv), (vi).

[25]For example, under 49 U.S.C. Chapter 445, FAA is to, among other things, conduct or supervise research on aviation safety and "other aviation issues related to developing and maintaining a safe and efficient air transportation system" (49 U.S.C. § 44505(c)), and may enter into cooperative agreements with federal and non-federal entities to conduct, encourage, and promote aviation research, engineering, and development, including the development of prototypes and demonstration models (49 U.S.C. § 44505(e)), and may make grants to institutions of higher education and nonprofit research organizations to conduct aviation research in areas the Administrator considers necessary for the long-term growth of civil aviation (49 U.S.C. § 44511(a)).

- **Office of Aerospace Medicine and the Civil Aerospace Medical Institute (CAMI).** To enhance aviation safety, CAMI focuses on people in the aviation system (e.g., pilots, flight attendants, passengers, and air traffic controllers) by applying known science to improve aerospace operations and to avoid aircraft accidents and incidents.
- **William J. Hughes Technical Center.** FAA also carries out research at its William J. Hughes Technical Center, where engineers, scientists, mathematicians, and technical experts work to modernize and sustain the National Aviation System, which includes the nation's air-traffic control facilities.

FAA's National Aviation Research Plan documents the agency's research goals, objectives, and outputs. This plan is developed through a process involving both internal FAA stakeholders and aviation industry stakeholders (the agency's Research, Engineering, and Development Advisory Committee); it is organized by the agency's research goals.[26]

[26]In 2017, we found that FAA's actions related to the management of its research and development (R&D) portfolio were not fully consistent with statutory requirements, agency guidance, and leading practices. Accordingly, we recommended that DOT direct FAA to (1) take a more strategic approach to identifying long-term R&D research priorities across the agency, (2) disclose how research projects are prioritized and selected, and (3) ensure that FAA's National Aviation Research Plan and R&D annual reviews meet statutory requirements for content. DOT agreed with and has subsequently implemented all three of these recommendations. For more information, see GAO-17-372.

Stakeholders Identified Additional Research Needed on Communicable Diseases in Air Travel and Challenges to Conducting It

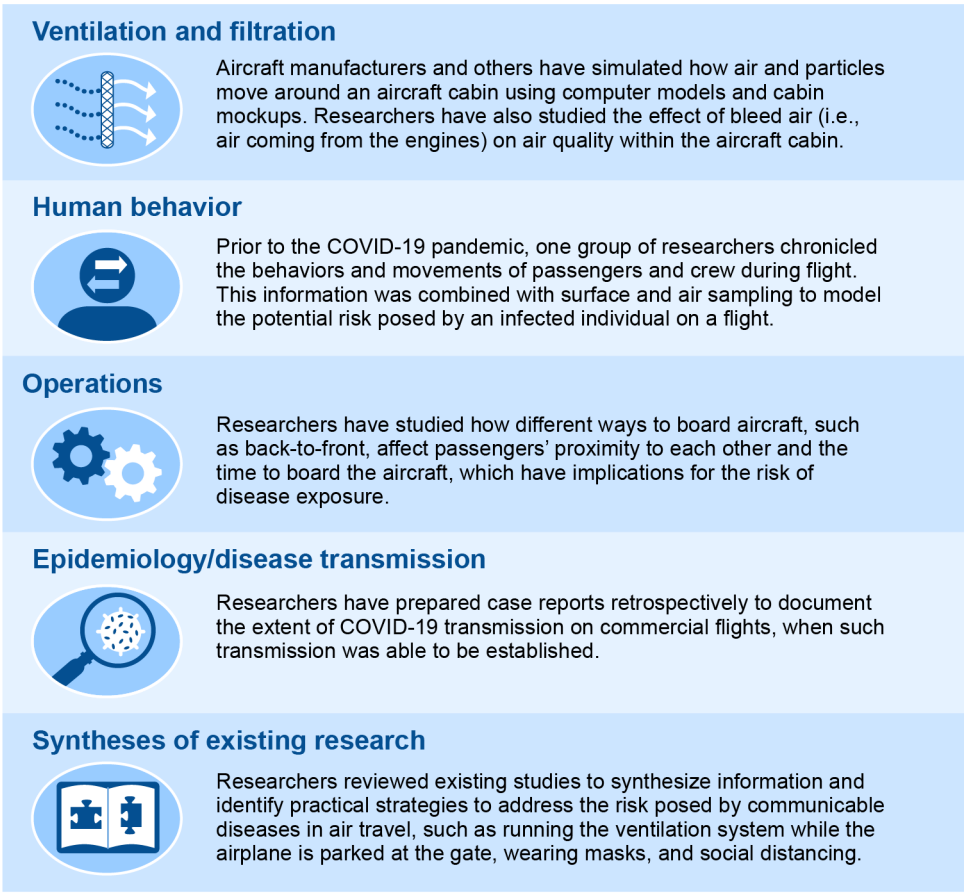
Existing Research Spans Several Areas

Research on communicable diseases in air travel spans several areas, such as ventilation and filtration, human behavior, and operations.[27] Figure 2 provides examples of this research, including work to assess the effects of layered mitigations to reduce disease transmission in air travel. While researchers have paid additional attention to the risk of communicable diseases in air travel during the pandemic, a portion of this work predates COVID-19. Some of this research—including studies on aircraft cabin ventilation and operations—was based on modeling. For example, researchers used computer, chemical, or biological models to simulate various scenarios in which communicable diseases could be transmitted in air travel.[28] For more information about research on communicable diseases in air travel, see appendix II.

[27]We identified relevant research through interviews with researchers and other stakeholders, as well as our review of academic literature, relevant news and publications, and our prior work. Our initial literature review identified peer-reviewed studies published in 2020 and included work conducted in a variety of research areas. For the purposes of this report, we have focused our findings on those research areas that are most salient to COVID-19. To better understand how the volume of research published on communicable diseases in air travel has changed over time, we performed two additional citation-count searches in Scopus, for academic journal articles and conference papers published from January 2011 through July 2021. We continued to monitor research publications through March 2022 and contacted researchers and agency officials to stay abreast of relevant research. See appendix I for more information about our literature review. See appendix II for additional information about research on communicable diseases in air travel, including selected citations. The research we identified does not include all research conducted on communicable diseases in air travel.

[28]For an example of research using computer modeling, see R. John Milne, Camelia Delcea, and Liviu-Adrian Cotfas, “Airplane Boarding Methods that Reduce Risk from COVID-19,” *Safety Science* 134, (2021). For an example of chemical modeling, see *TRANSCOM/AMC Commercial Aircraft Cabin Aerosol Dispersion Tests,* submitted to U.S. Transportation Command (TRANSCOM) and Air Mobility Command (AMC) (Oct. 15, 2020), which used tracer gases. For an example of a study using biological modeling techniques, see Watts L. Dietrich, James S. Bennett, Byron W. Jones, and Mohammad H. Hosni, “Laboratory Modeling of SARS-CoV-2 Exposure Reduction through Physically Distanced Seating in Aircraft Cabins using Bacteriophage Aerosol - November 2020,” *MMWR - Morbidity and Mortality Weekly Report* 70, no. 16 (Apr. 23, 2021): 595-599, which used bacteriophages.

Figure 2: Selected Research Areas for Communicable Diseases in Air Travel and Examples of Research



Source: GAO analysis of literature related to research and development on communicable diseases in air travel. | GAO-22-104579

Note: These areas were selected because they are relevant to COVID-19. For example, we did not include examples of research on surface cleaning and disinfection.

The real-world applicability of models is limited by assumptions they employ and the amount and quality of data needed to validate them, among other things. In some cases, researchers substituted known parameters as proxies for unknown ones, such as when researchers used the infectiousness of other diseases as a proxy for that of COVID-19. In another instance, researchers used a mannequin to stand in for passengers in a mock aircraft cabin to study the dispersion of aerosols and made other assumptions given the unknowns about the disease.

Results from this study on the potential time needed for disease transmission are hypothetical, according to the authors of the study.[29]

While much of the research we identified was conducted by researchers affiliated with universities or industry, a small proportion of the studies we identified on communicable diseases in air travel was sponsored or conducted by a federal partner.[30] In interviews, officials with CDC's NIOSH, DHS's Science and Technology Directorate, and FAA each provided examples of research conducted during the COVID-19 pandemic with varying relevance to disease transmission in air travel. These examples included:

- CDC's NIOSH, which focuses on occupational safety and health, conducted a study on the relative risk reduction of blocking middle seats. NIOSH researchers collaborated with academic researchers on this work, including an academic who had previously worked with FAA through a cabin air-quality research program that has now been discontinued, as is discussed later in this report.[31]
- DHS's Science and Technology Directorate performed various research on behalf of TSA, including modeling that may have relevance to disease transmission. This effort leveraged existing work

[29]TRANSCOM/AMC (2020). The authors of this study, conducted with sponsorship from United Airlines and Boeing, published a revised cover sheet for the study, which noted, "The authors of this study are concerned about the potential misinterpretation of the findings, based on some hypothetical calculations originally included as discussion points. In particular, the viral aerosol production rates, infectious dose and general assumptions used to estimate a flight time of 54 hours to produce an infection are hypothetical and were not designed to provide actionable information about viral risk during flight, safe flight times or seating capacity."

[30]In our initial literature review, for example, we identified eight studies that had a federal partner or sponsor, out of 66 studies, including one sponsored by the Center for Advanced Transportation Mobility and DOT. See Derjany, P., S. Namilae, D. Liu, and A. Srinivasan, "Multiscale Model for the Optimal Design of Pedestrian Queues to Mitigate Infectious Disease Spread," *Plos One* 15, no. 7 (2020). Other federal agencies sponsoring or partnering in research included National Science Foundation, CDC, HHS, the Veterans Administration, and the Department of Defense, including TRANSCOM. "Partnering" may simply mean that one of the coauthors on a study was affiliated with a federal agency. In addition, during our interviews, researchers at TSA described work that they had done in collaboration with the Environmental Protection Agency regarding disinfectants. For more information on our literature searches, see appendix I.

[31]Watts L. Dietrich, et al., "Laboratory Modeling of SARS-CoV-2 Exposure Reduction through Physically Distanced Seating in Aircraft Cabins using Bacteriophage Aerosol - November 2020," *MMWR - Morbidity and Mortality Weekly Report* 70, no. 16 (Apr. 23, 2021): 595-599.

intended to evaluate chemical terrorism to assess airflow onboard aircraft. In addition, the Directorate performed applied research in five areas related to TSA's operational needs at security checkpoints—ultraviolet disinfection of security bins, use of dogs to detect COVID-19, face coverings for TSA personnel, reuse of explosive trace detection swabs, and cleaning solutions.[32] The Directorate has also conducted additional work; some of which has been published in peer-reviewed journals and is posted on the agency's website.[33]

- In response to the COVID-19 pandemic, FAA has studied risks posed by carrying large quantities of dry ice needed for the transport of COVID-19 vaccines, as well as the effect of increased disinfectant use on aircraft materials. These efforts focus on safety questions related to the aircraft but do not include an assessment of the disease infection risk to the aircraft's occupants. In addition, FAA researchers within the agency's Office of Aerospace Medicine told us they were developing a general model for communicable disease transmission in aircraft cabins based on existing disease transmission models. According to FAA officials, this modeling work was initiated in response to GAO testimony and draft fiscal year 2021 House appropriations committee language.[34]

Prior to the COVID-19 pandemic, FAA supported research on the air cabin environment. Specifically, that work was performed from 2004 through 2014 under the aegis of the National Center of Excellence for Airliner Cabin Environment Research (ACER), which was established by FAA's former Office of Regulation and Certification in response to congressional actions, as described below.[35] ACER brought together airliner cabin environment expertise from academic, industry, and government organizations and published reports addressing disease transmission in airliner cabins, the health effects of aircraft cabin pressure

[32]For more information, see GAO, *COVID-19: TSA Could Better Monitor Its Efforts to Reduce Infectious Disease Spread at Checkpoints,* GAO-21-364 (Washington, D.C.: June 14, 2021).

[33]For more information including links to peer-reviewed articles, see DHS, "Probabilistic Analysis for National Threats Hazards and Risks (PANTHR)," accessed January 20, 2022, https://www.dhs.gov/science-and-technology/panthr.

[34]See GAO-20-655T. Several laws have required FAA to study cabin air quality and associated health effects. Besides work conducted in response to such statutory mandates and its recently initiated modeling work in response to COVID-19, FAA has not independently pursued research on communicable diseases in air travel since 2003. Appendix III describes a selection of these laws and research since 1994.

[35]In 2007, the ACER was broadened and renamed the National Air Transportation Center of Excellence for Research in the Intermodal Transport Environment (ACERite).

in older and vulnerable passengers, and decontamination technologies for use on narrow-body and wide-body aircraft, among other topics.

Stakeholders Said More Real-World Research Is Needed to Better Protect Passengers and Crew

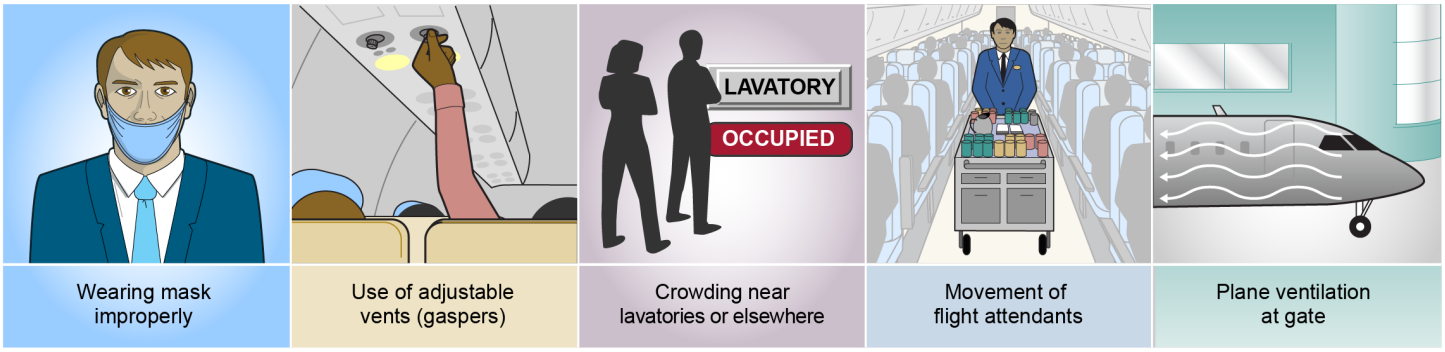
All of the researchers we spoke with identified additional research on communicable diseases in air travel—especially involving real-world situations and human behavior—that is still needed to better understand transmission risks. This additional research could help address limitations in the models used in some research conducted thus far and inform practices and policies that could better protect passengers and crew members.[36]

Researchers in various fields described to us the need for more research spanning various disciplines that involves real-world situations and human behavior aboard aircraft and in airports (see fig. 3). For example, in the area of ventilation and filtration, researchers pointed to the need for more work characterizing airflow in aircraft, including when passengers use adjustable vents above their seats, and in airport locations with crowds, such as at security checkpoints or in boarding areas. Infectious disease researchers, in particular, said that more research to identify where transmission occurred in specific cases (i.e., in-flight or elsewhere in the travel journey) would be beneficial.[37]

[36]Our review identified only one real-world study on COVID-19 and commercial flights that included passengers prior to flight—in contrast to epidemiological studies performed after the fact to document cases of potential disease transmission. This study, conducted by Delta Air Lines in coordination with academic researchers, looked at the effectiveness of testing passengers 72 hours prior to departure. See Aaron J. Tande, et al., "SARS-CoV-2 Testing Prior to International Airline Travel, December 2020-May 2021," *Mayo Clinic Proceedings* (November 2021). For more information on airlines' testing and tracing practices, see GAO, *Contact Tracing for Air Travel: CDC's Data System Needs Substantial Improvement,* GAO-22-105018 (Washington, D.C., July 11, 2022).

[37]DHS officials added that research is also needed on inflight airflow, filter efficiency as a function of aircraft age, and any impact on airflow when adjusting the ratio of fresh to recycled air.

Figure 3: Examples of Conditions or Behaviors on an Airplane That May Affect Disease Transmission



Source: GAO illustration of information provided by stakeholders. | GAO-22-104579

A better understanding of the transmission of COVID-19 and other diseases in real-world air travel situations could help researchers improve their models and could lead to safer practices. For example, once the infectious doses and transmission modes of SARS-CoV-2 and other diseases are better understood, infectious diseases experts could help operations researchers improve their models. Operations researchers studying how passengers board aircraft—such as boarding aircraft from back to front—could then replace the proxies used to develop models with empirical data.

Stakeholders—including a travel medicine researcher, an epidemiologist who studies respiratory diseases, and representatives from the flight attendants union with expertise in industrial hygiene and occupational safety and health—also told us that research to better inform policies that affect flight and cabin crews would be beneficial because of their potential exposure to communicable diseases while on the job. Specifically, representatives for the Association of Flight Attendants advocated for additional research on disease exposure onboard an aircraft. They raised concerns that current guidelines may put the health and safety of flight attendants and passengers at risk, with implications for quarantine and work-time requirements.[38] For example, current guidelines define disease exposure as being within 6 feet of an infected individual for at least 15 minutes. These representatives told us that flight attendants' actions—such as moving a sick passenger—could still put them at risk, even if these actions do not strictly meet the definition of exposure. (See fig. 4.)

[38]As of April 2022, for COVID-19, CDC defines exposure as being within 6 feet of someone who has COVID-19 for a cumulative total of 15 minutes or more over a 24-hour period.

Figure 4: CDC Guidelines for Potential Exposure to Communicable Diseases in Flight

Sources: CDC, GAO and Yaroslav Astakhov/ adobe.stock.com. | GAO-22-104579

Stakeholders Identified a Range of Challenges to Conducting Needed Research

Stakeholders, including researchers, consumer advocates, and union representatives, described the following challenges to conducting research on communicable diseases in air travel:

- **Lack of access to aircraft, airports, and relevant data.** Stakeholders said this lack of access is an obstacle to conducting needed real-world research. One researcher said that ACER, a former FAA-sponsored Center of Excellence, paired researchers with industry, and that once that center ended, it became difficult for researchers to access aircraft.[39] Other researchers said that difficulty accessing aircraft and airports posed a challenge to performing research on airborne diseases in those environments. The

[39]We will discuss this center of excellence below. For more information about such centers, see FAA, "FAA Air Transportation Centers of Excellence," accessed January 21, 2022, https://www.faa.gov/about/office_org/headquarters_offices/ang/grants/coe.

researchers also stated that it can be difficult to carry out interdisciplinary research given the complexity of jurisdictions in air travel. For example, a travel medicine researcher explained that as passengers move through airports and travel aboard aircraft, they are under the jurisdiction of local, state, and federal authorities, among others. Obtaining permission from the appropriate authorities can present an obstacle to even something as simple as asking passengers to fill out a questionnaire or collecting a nasal swab. Finally, researchers across several areas—including government researchers—told us they could not easily obtain data needed to improve their models, such as detailed information on cabin characteristics from aircraft manufacturers or airline-boarding practices from airlines.

- **Lack of sustained support from the federal government and industry.** Researchers told us it has been difficult to obtain federal support to study communicable diseases in air travel, particularly as interest in such research has historically waxed and waned with disease outbreaks. Researchers in several areas also explained that this interdisciplinary topic may fall in the gaps between different funding agencies. One researcher told us that if a university-based scientist went to the National Institutes of Health (NIH) for funding to study disease transmission in air travel, for example, NIH might redirect the scientist to CDC, which might, in turn, redirect the scientist to FAA, which might ultimately say this work is outside its purview. Another researcher told us that because each agency has its own niche, it is difficult to find support for needed interdisciplinary work.

  Continuity of industry funding for work on communicable diseases can also be limited. For example, the research assessing passenger movement and disease transmission on aircraft was conducted with industry funding and support.[40] According to the researchers who conducted this work, when corporate funding ended, the authors were not able to pursue follow-on research. One researcher told us that industry sponsors have a built-in bias to find good news. Similarly, another researcher said that airlines and airplane manufacturers may be reluctant to fund or pursue research that could have an adverse effect on their business, such as research that might suggest changes to overhead bin access or food and drink service.

[40]Vicki Stover Hertzberg, et al., “Behaviors, Movements, and Transmission of Droplet-Mediated Respiratory Diseases during Transcontinental Airline Flights,” *Proceedings of the National Academy of Sciences* 115, no. 14 (Apr. 3, 2018): 3623-3727.

- **Lack of federal leadership.** Given the multiple partners potentially involved in this interdisciplinary work—including various federal agencies, as well as academic, nonprofit, and industry representatives—stakeholders told us that federal leadership is needed to identify and address gaps in research, corroborate research findings, and help assure objectivity of research. In particular, some stakeholders had concerns about the credibility of industry-funded research. Stakeholders said stronger federal leadership could bolster public trust in the validity of research findings. Federal leadership could also facilitate more timely recommendations to protect the traveling public. With regard to the COVID-19 pandemic specifically, stakeholders—including researchers with a focus on ventilation—described inaction or delays in promulgating federal policies that could better protect passengers, such as requiring that airlines run aircraft ventilation systems on the ground or that passengers wear masks.[41]

Absence of Federal Leadership Has Hindered the Advancement of Research on Communicable Diseases in Air Travel

Federal Agencies Have Focused on Research Areas Relevant to their Missions

While each of the agencies in our review has conducted some research relevant to communicable diseases in air travel, none of them has undertaken efforts to advance such research more broadly, according to agency officials we interviewed. Rather, these agencies have focused on the specific research areas most relevant to their priorities and mission, as described above. However, officials with both FAA's CAMI and CDC's Division of Global Migration and Quarantine told us that a more coordinated federal approach and support for relevant research could generate valuable information and inform policy development and guidance. Such research could include studying how people behave during air travel or the ventilation necessary to protect passengers in realistic environments, among other areas of research identified by stakeholders and discussed above.

[41]ACRP (2013) recommended that aircraft reduce ventilation downtime when parked at the gate in 2013.

We found that each of the agencies in our review has key expertise and assets that could be leveraged to identify and advance additional research that the various stakeholders we interviewed said was needed. (See table 2.)

Table 2: Examples of Federal Assets and Expertise for Advancing Research on Communicable Diseases in Air Travel

Centers for Disease Control and Prevention (CDC)	• CDC has broad public health expertise, as well as expertise in epidemiology, which is the study of the incidence, distribution, and control of diseases in a population. • Within the agency, the Division of Global Migration and Quarantine (DGMQ) has access to findings from ongoing surveillance and contact tracing efforts, and the National Institute for Occupational Safety and Health (NIOSH) has access to workplace exposure assessments. • In response to the COVID-19 pandemic, NIOSH developed a research agenda to address occupational health research gaps, including those affecting airline and airport personnel.
Department of Homeland Security (DHS)	• DHS's Science and Technology Directorate has the ability to conduct relevant basic and applied research, and the Transportation Security Administration (TSA) has extensive knowledge of the security process at airports. • DHS has also developed "master question lists" for several communicable diseases since the Ebola outbreak in 2014, with key questions that could be addressed through additional research.[a]
Federal Aviation Administration (FAA)	• FAA has aeromedical expertise, facilities, and equipment through the Office of Aerospace Medicine and the Civil Aerospace Medical Institute (CAMI). • In response to the COVID-19 pandemic, FAA has plans to work with public health authorities to validate ongoing modeling work on disease transmission in the aircraft cabin based on existing disease transmission models. • FAA also has established relationships with domestic and international entities involved in the response to communicable disease threats as they relate to aviation, as well as with manufacturers. • The Department of Transportation (DOT) and FAA also have strong ties to key aviation stakeholders, such as international civil aviation organizations, as well as oversight responsibilities for airlines, airports, and other members of the aviation industry.

Source: GAO analysis of information from selected federal agencies. | GAO-22-104579

[a]DHS and the Science and Technology Directorate first developed a "master question list" in response to the 2014–2015 Ebola outbreak to collect high-level research questions derived from open, reliable, vetted sources. This list allowed the agency to focus on those questions for which the agency's response was best qualified. Subsequently, master question lists have been developed for other topics, including synthetic opioids, African Swine Fever virus, and now COVID-19. For the dedicated COVID-19 master question list, see DHS "Master Question List for COVID-19 (caused by SARS-CoV-2)," accessed May 19, 2022, https://www.dhs.gov/publication/st-master-question-list-covid-19.

Agency officials in our review described challenges to conducting interdisciplinary research—even among federal agencies. For example, a CAMI official told us that it is difficult to know what other agencies' research activities and competencies are, given their overlapping mission areas and various ways of doing business. Similarly, a NIOSH official told us that research on communicable diseases in air travel often involves different areas of expertise and various sectors, making it difficult to conduct in the absence of leadership to bring entities together. For

example, such research might involve both epidemiological and engineering expertise as well as public-health and aviation-related data. In particular, FAA officials stressed the importance of engaging expertise from various agencies to address challenges posed specifically by the COVID-19 pandemic. Similarly, officials with DHS's Science and Technology Directorate pointed out that the agency has different kinds of expertise relevant to aircraft cabin exposure research than does FAA.[42]

We have found in prior work that federal research can benefit from effective interagency collaboration, such as when the National Aeronautics and Space Administration (NASA) collaborated with FAA for technology transfers between these agencies, resulting in the use of NASA-developed software by FAA's air traffic controllers.[43] Such coordination can be implemented in a variety of ways, including developing national strategies and designating leadership.[44] In particular, national strategies can provide a framework for addressing issues that cut across federal agencies and sectors, while designation of leadership—such as designating one agency or department to be accountable for a strategy—can be useful if an effort requires the contribution of several different agencies exercising different statutory authorities.

We have also found that these approaches can be enhanced and sustained when they incorporate leading practices for interagency collaboration, such as clearly identifying roles and responsibilities, determining resources needed, and documenting any relevant agreements. A federal strategy that has clear leadership and that incorporates these leading practices could enable participating agencies to advance needed research on communicable diseases in air travel in a coordinated manner and over the long term.

[42]The Chief Scientist with DHS's Science and Technology Directorate pointed to differing areas of research expertise regarding aircraft cabin exposures to illustrate the potential impact of interagency collaboration. According to this official, while FAA has done significant work through ACER in the transmission of disease on aircraft and longer-term exposures on air-cabin quality, DHS's Science and Technology Directorate and TSA have done significant work on transmission of bioagents and exposure to toxic chemicals.

[43]For more information, see GAO-17-372.

[44]We have previously examined interagency collaborative mechanisms and identified certain key issues for federal agencies to consider when using these mechanisms to achieve results. For more information about the key features of interagency collaboration, see appendix I and GAO-12-1022.

FAA's Tentative Plan to Continue Research Is Narrow, but It Has Broad Authority to Do More

While FAA acknowledges that it has broad statutory authority to conduct and sponsor research related to aviation safety, the extent to which the agency intends to be involved in research on communicable diseases in air travel over the long term is unclear. FAA's plan for research on communicable diseases in air travel is tentative and narrow, and the agency currently has no plan to provide sustained support for interdisciplinary research in this field.

In July 2021, FAA's Office of Aerospace Medicine issued a strategic plan for research that included a new focus called "communicable disease preparedness and response."[45] According to the plan, this effort would include research on cabin health safety (i.e., the agency's ongoing modeling work), as well as potential research addressing COVID-19 effects on medical certification for aviators.[46] However, FAA officials indicated that support and funding for these efforts is uncertain, as the plan's execution would be subject to appropriations and congressional direction. Furthermore, FAA has not made clear whether such an initiative will be integrated into overall agency priorities for research, particularly whether it will become part of FAA's National Aviation Research Plan.

Although FAA is now examining its role in communicable disease research, it has historically maintained that the risk posed by communicable diseases in air travel is a public health concern that is separate from the agency's core responsibilities for flight safety. FAA acknowledges that it has broad authority to promote safe flight of civil aircraft in air commerce by prescribing regulations and minimum

[45]FAA, Aviation Safety, *Aerospace Medicine R&D Strategic Plan* (Washington, D.C.: July 17, 2021).

[46]The plan also includes research support for a portion of the agency's regulatory portfolio addressing airman medical certification and may also foreshadow future work addressing aspects of disease surveillance, although no details are provided for the latter within the plan.

standards for a wide range of aviation-safety-related matters.[47] In interviews, however, FAA officials emphasized that health safety is separate from aviation safety and that, in general, issues related to health safety—such as an individual's exposure to pathogens and subsequent sickness—should be considered public health issues and are the purview of agencies such as the CDC and HHS. While FAA's authorities do not specifically address the protection of crewmembers and passengers against communicable diseases, such a role in the aviation-safety context is not necessarily precluded.[48]

According to FAA, the agency has statutory authority to conduct a wide range of research and development related to aviation safety, as well as to make grants to other organizations.[49] FAA has previously—although usually in response to statutory mandates—undertaken research to address health and safety, including research relevant to communicable diseases in air travel.[50] For example, as previously noted, the agency sponsored research on the air cabin environment under the aegis of the National Center of Excellence for Airliner Cabin Environment Research

[47]Under 49 U.S.C. § 44701, the Administrator of the FAA shall promote safe flight of civil aircraft in air commerce by prescribing, among other things, "other practices, methods, and procedure the Administrator finds necessary for safety in air commerce and national security." 49 U.S.C. § 44701(a)(5). According to FAA, this authority could potentially underpin actions taken on the basis of research results if such results provided information reasonably related to the promotion of the safe flight of civil aircraft in air commerce that indicated the need for FAA regulatory action.

[48]According to FAA, applicable statutes and case law provide the FAA with authority to protect crewmember and passenger health with rules if they are reasonably related to flight safety. In this light, the D.C. Circuit has held that "'health' is a component of 'safety'" and includes "protecting passengers' physical health in flight, even from harms that are not occasioned by the flight." *Flyers' Rights Education Fund, Inc. v. FAA*, 864 F.3d 738, 748 (D.C. Cir. 2017) (citing *Bargmann v. Helms*, 715 F.2d 638, 641-43 (D.C. Cir. 1983) (ruling that FAA has the authority to regulate first aid kits for treating conditions that occur during the flight, whether or not those conditions are caused by flight conditions or operations). The D.C. Circuit explained in *Flyers' Rights* that "…there is no question that the Administration has the statutory authority to address at least some passenger health issues. [citation omitted]." *Flyers' Rights,* 864 F.3d at 748. According to FAA, however, the precise extent to which health and safety overlap in the aviation context is not clearly defined in the case law.

[49]See various sections of 49 U.S.C. Chapter 445. For example, pursuant to 49 U.S.C. § 44513, the FAA may make grants to institutions of higher education that are members of FAA regional centers of air transportation excellence for "aviation safety and security" and "other aviation issues related to developing and maintaining a safe and efficient air transportation system." 49 U.S.C. § 44513(b)(1)(A)(iv), (vi).

[50]For examples of such research, see appendix III.

(ACER), which FAA established in 2004 in response to congressional actions.[51] For the 10 years that it was in operation, ACER brought together experts on airliner cabin environments from academic, industry, and government organizations. ACER published reports on topics such as disease transmission in airliner cabins, the health effects of aircraft cabin pressure in older and vulnerable passengers, decontamination technologies for use on narrow-body and wide-body aircraft, and the health effects of "bleed air" in aircraft cabins.[52] However, outside of work undertaken in response to statutory mandates, and its recently initiated modeling work in response to COVID-19, FAA has not independently pursued research on communicable diseases in air travel since at least 2003.

This previous experience, as well as strong ties with key aviation stakeholders, suggests that FAA would be best positioned for the lead role in developing and implementing a strategy to advance research on communicable diseases in air travel, in coordination with other federal agencies, such as DHS and HHS, and external stakeholders. Such a strategy would help focus research efforts to better inform the development of policies and requirements to protect the health of passengers and crew. Although agency officials have said the precise contours of potential FAA authority are not well defined, such a role would be consistent with DOT's recent agreement to develop a national

[51]ACER was established in 2004 by FAA in response to a statutory mandate and language in a Senate appropriations committee report. Pub. L. No. 108-176, § 815, 117 Stat. 2490, 2592 (2003); S. Rep. No. 108-146 at 28 (2003). According to DOT, in 2014, the ACER/ACERite Center of Excellence completed mandated tasks and FAA-sponsorship for the center ended. In general, FAA Air Transportation Centers of Excellence, such as ACER, are to serve as a primary source of subject-matter expertise for an agreed upon 10 years. After this time, the Center must be self-supporting to continue, if agency funding is not extended.

[52]For example, see ACERite, *Infectious Disease Transmission in Airliner Cabins,* RITE-ACER-CoE-2012-01 (Washington D.C.: Feb. 22, 2012), among other studies. After ACER had ended in 2014, FAA was able to reconvene researchers who had previously been involved in the Center for cabin air-quality research initiatives focusing more specifically on "bleed air" and potential contaminants. Bleed air is outside air that is drawn through jet engines into an aircraft cabin. For more information about bleed air, see Gregory A. Day, *Aircraft Cabin Bleed Air Contaminants: A Review,* Civil Aerospace Medical Institute, FAA (Oklahoma City, OK: November 2015). FAA officials told us that they were subsequently unable to reconvene this expertise, given that the researchers had largely dispersed and moved on to other work.

aviation-preparedness plan, as discussed above.[53] However, absent congressional direction, FAA is unlikely to independently adopt such a leadership role.

Conclusions

The COVID-19 pandemic has intensified ongoing concerns about air travel's unique role in spreading disease and raised questions about the safety of passengers and crew. More interdisciplinary research—especially involving human behavior and real-world situations—is needed to better understand the risks of disease transmission in air travel. Such research could provide insights into the effectiveness of various mitigation measures and inform the development of evidence-based policy and requirements to protect public health.

While federal agencies have made some efforts to expand knowledge in this field, a federal strategy is needed to advance, coordinate, and leverage this critical research. Bringing various agencies' assets—including those of FAA, DHS, and HHS—to bear could link researchers with aviation stakeholders across areas of expertise, provide clearer access to federal funding for research, and help identify needed research across different disciplines. With FAA's broad authorities to protect aviation safety and its oversight responsibilities for and ties with aviation stakeholders, FAA is well positioned to take the lead in developing and implementing such a strategy. However, FAA officials' past statements and responses to our recent inquiries indicate that absent direction from Congress, the agency is unlikely to assume this role on its own initiative.

[53]We have recommended that DOT develop a national aviation-preparedness plan for communicable diseases since 2015 in coordination with relevant stakeholders, such as HHS and DHS. In April 2020, we had included this open recommendation as one of 16 high priority recommendations to DOT. With the onset of the COVID-19 pandemic, given DOT's inaction on this recommendation, we had urged Congress in June 2020 to take legislative action to require DOT to work with other agencies to develop the plan. As of July 2022, according to agency officials, DOT plans to take the lead, working closely with DHS and HHS, in developing such a plan for communicable diseases building upon the *Runway to Recovery* (FAA, 2020) and guidance materials from the International Civil Aviation Organization. According to agency officials, DOT intends to complete and implement the preparedness plan in 2023. For more information, see GAO-16-127; GAO, *Priority Open Recommendations: U.S. Department of Transportation,* GAO-20-513PR (Washington, D.C.: Apr. 23, 2020); and GAO, *Covid-19: Opportunities to Improve Federal Response and Recovery Efforts,* GAO-20-625 (Washington, D.C.: June 25, 2020).

Matter for Congressional Consideration

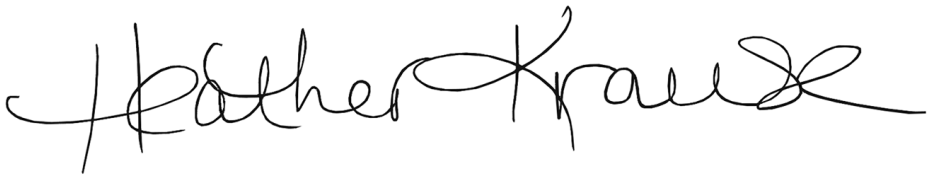
Congress should consider directing FAA to develop and implement a strategy to identify and advance needed research on communicable diseases in air travel, in coordination with appropriate federal agencies, such as DHS and HHS, and external partners. In alignment with leading practices for interagency collaboration, this strategy should, at a minimum, clearly identify the roles and responsibilities for participating agencies, determine the resources needed, and document any relevant agreements. (Matter for Consideration 1)

Agency Comments

We provided a draft of this report to DOT, HHS, and DHS for review and comment. Each of these agencies provided us with technical comments. Officials with DOT and DHS suggested that the matter for congressional consideration be directed to all three agencies. We agree that interagency collaboration will be necessary for the development and implementation of a national strategy to identify and advance needed research. Given that DOT and FAA have primary responsibility for overseeing the aviation sector, we believe that FAA is best positioned to work with relevant stakeholders to lead this effort. We have added DHS and HHS to our matter, however, to provide examples of appropriate federal agencies that should be included in any interagency collaboration.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Transportation, the Secretary of Health and Human Services, the Secretary of Homeland Security, and other interested parties. In addition, the report is available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions about this report, please contact Heather Krause at (202) 512-2834 or krauseh@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix IV.



Heather Krause
Director, Physical Infrastructure

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Subcommittee on Aviation
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Appendix I: Objectives, Scope, and Methodology

We began this review under GAO's CARES Act authority.[1] We subsequently received requests from the House Committee on Transportation and Infrastructure and its Aviation Subcommittee, as well as the House Committee on Science, Space, and Technology. This report examines: (1) the status of research on communicable diseases in air travel, including stakeholders' views on additional needed research and challenges to conducting it, and (2) the extent to which FAA and other federal agencies are advancing such research. For the purposes of our review, air travel is comprised of passengers' and crews' movement through the airport, on and off aircraft, and in flight, but our scope does not include air travel's role in facilitating the spread of a disease to different locations, or between different modes of transportation (e.g., airport to bus or transit system). Our focus is on communicable diseases that are spread through human contact.[2]

This report builds on our prior work addressing communicable diseases in air travel and FAA's research. In 2015, in response to the Ebola epidemic, we reviewed the preparedness of the U.S. aviation system to respond to communicable disease threats, and recommended that the Department of Transportation (DOT) develop a national aviation-preparedness plan for communicable diseases, a recommendation that DOT intends to complete and implement in 2023, according to agency officials.[3] In 2017, we reviewed how FAA manages its research portfolio, and made three

[1]Pub. L. No. 116-136, § 19010(b), 134 Stat. 281, 579-80 (2020). We regularly issue government-wide reports on the federal response to COVID-19. For the latest report, see GAO, *COVID-19: Current and Future Federal Preparedness Requires Fixes to Improve Health Data and Address Improper Payments,* GAO-22-105397 (Washington, D.C.: Apr. 27, 2022).

[2]Some infectious diseases are contagious (or communicable), that is, spread from one person to another. Other infectious diseases can be spread by germs carried in air, water, food, or soil. They can also be spread by vectors (like biting insects) or by animals. For purposes of this report, we are focused on those communicable diseases that might be spread from person to person during travel.

[3]GAO, *Air Travel and Communicable Diseases: Comprehensive Federal Plan Needed for U.S. Aviation System's Preparedness,* GAO-16-127 (Washington, D.C.: Dec. 16, 2015).

recommendations that FAA has implemented.[4] In June 2020, we provided a status update on these two earlier reports.[5]

To examine the status of research on communicable diseases in air travel and challenges to conducting it, we reviewed academic literature, monitored relevant news and publications, and interviewed researchers and other stakeholders, as discussed below. To form the basis of our review of academic literature, we performed a literature search to identify research conducted in 2020 on communicable disease transmission and air travel, including COVID-19, using ProQuest, Dialog, and Scopus. Our search included results from peer-reviewed scholarly publications, conference papers, government reports, trade association and think tank publications, among others, and it excluded general news articles, working papers, and legislative materials. To better understand how the volume of research published on communicable diseases in air travel has changed over time, we performed two additional citation-count searches in Scopus, for academic journal articles and conference papers published from January 2011 through July 2021. To stay abreast of relevant research, we continued to monitor open-source literature through March 2022 and contacted researchers and agency officials.

We interviewed a nongeneralizable selection of stakeholders, including researchers engaged in relevant work, especially with regard to COVID-19, as well as aviation stakeholders and agency officials, as described below. We identified these stakeholders through open-source research, our literature search, and through interviews. We sought to interview researchers in a variety of areas (see table 3).

Table 3: Researchers Interviewed to Solicit Views on Communicable Diseases in Air Travel

Research area	Researcher	Selected relevant research areas
Ventilation and filtration	Joe Allen, DSc, MPH, CIH	Environmental health, indoor air quality
	Linsey Marr, PhD	Environmental engineering, bioaerosols, viruses in the built environment
	Donald Milton, MD, DrPH	Environmental and occupational health, airborne infection transmission, bioaerosols

[4]GAO, *Aviation Research and Development: FAA Could Improve How It Develops Its Portfolio and Reports Its Activities,* GAO-17-372 (Washington, D.C.: Apr. 24, 2017).

[5]GAO, *Air Travel and Communicable Diseases: Status of Research Efforts and Action Still Needed to Develop Federal Preparedness Plan,* GAO-20-655T (Washington, D.C.: June 23, 2020).

Research area	Researcher	Selected relevant research areas
	David Silcott	Biodefense, bioaerosol detection, sensors
	Sean Kinahan	Detection and characterization of biological aerosols
Human behavior	Vicki Hertzberg, PhD	Biostatistics, disease transmission and human behavior on airplanes
	Howard “Howie” Weiss, PhD	Microbial genetics, disease dynamics, dynamics of microbiomes, mathematical modeling
Operations	R. John Milne, PhD	Operations research methods to determine airplane seat assignments and passenger boarding sequences
	Sirish Namilae, PhD	Computational modeling of pedestrian dynamics, multiscale modeling
Epidemiology/disease transmission	David Freedman, MD	Infectious diseases, travel medicine, global surveillance of infectious diseases
	Richard Martinello, MD	Infectious diseases including molecular epidemiology and the transmission of respiratory viruses, infection prevention
	Robert “Chip” Schooley, MD	Infectious diseases including diagnosis, pathogenesis and therapy of viral infections, global health
	Henry Wu, MD	Infectious disease epidemiology, travel medicine
Syntheses of existing research	Leonard “Lenny” Marcus, PhD	Emergency preparedness and response, leadership
	Edward “Ed” Nardell, MD	Airborne transmission of infectious diseases, infection prevention strategies
	John “Jack” Spengler, PhD	Environmental health, indoor air quality
Bioethics	Lisa M. Lee, PhD	Bioethics, public health and ethics at the local, state, and federal levels

Source: GAO. | GAO-22-104579

We also spoke with federal agency officials who might have a research role related to communicable diseases in air travel. They included officials at FAA’s Office of Aerospace Medicine and its Civil Aerospace Medical Institute (CAMI), the National Institute for Occupational Safety and Health (NIOSH) within the Centers for Disease Control and Prevention (CDC), and the Department of Homeland Security’s (DHS) Science and Technology Directorate. In addition, we interviewed the chair of the Research, Engineering, and Development Advisory Committee (REDAC), which is the advisory body for FAA’s research portfolio, and officials with the Airport Cooperative Research Program of the Transportation Research Board. We spoke with selected aviation stakeholders, as well, to understand how communicable diseases affect air travel, including the practical effects of research on policy, including representatives from unions, aviation industry organizations, and one airline (see table 4).

Table 4: Additional Aviation Stakeholders Interviewed

Air Line Pilots Association	https://www.alpa.org/

Airlines for America	https://www.airlines.org/
Airport Council International–North America	https://airportscouncil.org/
Association of Flight Attendants-CWA	https://www.afacwa.org/
Consumer Reports	https://www.consumerreports.org/
Delta Air Lines	https://www.delta.com/
RTCA[a]	https://www.rtca.org/

Source: GAO. | GAO-22-104579

[a]RTCA, a private nonprofit association founded in 1935 as the Radio Technical Commission for Aeronautics, is now referred to simply as "RTCA."

To examine the extent to which FAA and other federal agencies are advancing research on communicable diseases in air travel, we reviewed relevant statutes, our prior reports, and documentation of federal agencies' actions and plans, such as FAA's latest National Aviation Research Plan and presentation materials for REDAC meetings. We also interviewed officials from DOT's Office of the Assistant Secretary for Research and Technology, as well as a variety of FAA offices, including the Office of Aerospace Medicine and CAMI within it, the Williams J. Hughes Technical Center, the Office of National Security Programs and Incident Response, and the Office of Airports and the Flight Standards Service.

In addition to DOT and FAA, we interviewed officials and reviewed documentation from other selected relevant agencies, including the Division of Global Migration and Quarantine (DGMQ) and NIOSH at the CDC, and the Transportation Security Administration (TSA) and the Science and Technology Directorate at DHS. In addition to these agencies, we solicited input from the National Institute of Allergy and Infectious Diseases (NIAID) at the National Institutes of Health (NIH). We identified these agencies based on our initial entrance with FAA and internal discussions with GAO stakeholders. We also reviewed mission statements, research plans, and other relevant documentation, for DGMQ, NIOSH, NIAID, and TSA, in addition to conducting interviews or collecting written responses from each of these agencies.

We assessed key considerations for interagency collaboration, including collaborative mechanisms and associated leading practices identified in

our prior work.[6] This work identifies "collaboration" broadly as any joint activity that is intended to produce more public value than could be produced when agencies act alone. Table 5 includes key features of effective interagency collaboration. For the purposes of a collaborative strategy for research on communicable diseases in air travel, relevant features include identifying leadership, clarifying roles and responsibilities, determining resources needed, and documenting relevant agreements.

Table 5: Key Features of Effective Interagency Collaboration

Outcomes and Accountability	Have short-term and long-term outcomes been clearly defined? Is there a way to track and monitor their progress?
Bridging Organizational Cultures	What are the missions and organizational cultures of the participating agencies? Have agencies agreed on common terminology and definitions?
Leadership	How will leadership be sustained over the long-term? If leadership is shared, have roles and responsibilities been clearly identified and agreed upon?
Clarity of Roles and Responsibilities	Have participating agencies clarified roles and responsibilities?
Participants	Have all relevant participants been included? Do they have the ability to commit resources for their agency?
Resources	How will the collaborative mechanism be funded and staffed? Have online collaboration tools been developed?
Written Guidance and Agreements	If appropriate, have participating agencies documented their agreements regarding how they will be collaborating? Have they developed ways to continually update and monitor these agreements?

Source: GAO. | GAO-22-104579

We conducted this performance audit from October 2020 to July 2022 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

[6]See GAO, *Managing for Results: Key Considerations for Implementing Interagency Collaborative Mechanisms,* GAO-12-1022 (Washington, D.C.: Sep. 26, 2012). Prior GAO work applies key features of interagency collaboration from this work to research in GAO-17-372 and GAO, *Antibiotic Resistance: Additional Federal Actions Needed to Better Determine Magnitude and Reduce Impact,* GAO-20-341 (Washington, D.C.: Mar. 30, 2020).

Appendix II: Selected Research on Communicable Diseases in Air Travel

We identified research done in a variety of areas as part of our review on the status of research on communicable diseases in air travel. For example, we found studies assessing different queuing and boarding techniques (e.g., from the rear of the plane), which were conducted by university researchers with expertise in operations or engineering using computer models. We also identified an initiative to synthesize existing research on the effects of layered mitigations in reducing disease transmission in air travel that had been conducted by university researchers with the support of industry. Table 6 includes selected citations for areas of research that we identified as being relevant for COVID-19.

Table 6: Selected References for Research Areas Related to Communicable Diseases in Air Travel

Selected research areas	Selected citations
Ventilation and filtration	Bull, Karen. “Cabin Air Filtration: Helping to Protect Occupants From Infectious Diseases.” Travel Medicine and Infectious Disease 6 (2008): 142–144. https://doi.org/10.1016/j.tmaid.2007.08.004. Dai, Hui, Zhao, Bin. “Association of the Infection Probability of COVID-19 with Ventilation Rates in Confined Spaces. Building Simulation 13, (2020): 1321–1327. https://doi.org/10.1007/s12273-020-0703-5. TRANSCOM/AMC Commercial Aircraft Cabin Aerosol Dispersion Tests, submitted to U.S. Transportation Command (TRANSCOM) and Air Mobility Command (AMC) (Oct. 28, 2020).
Human behavior	Hertzberg, Vicki Stover, Howard Weiss, Lisa Elon, Wenpei Si, Sharon L. Norris, and The FlyHealthy Research Team. “Behaviors, Movements, and Transmission of Droplet-Mediated Respiratory Diseases during Transcontinental Airline Flights.” Proceedings of the National Academy of Sciences 115, no. 14 (National Academy of Sciences, 2018): 3623-3627. https://doi.org/10.1073/pnas.1711611115.

Selected research areas	Selected citations
Operations	Derjany, P., S. Namilae, D. Liu, and A. Srinivasan. “Multiscale Model for the Optimal Design of Pedestrian Queues to Mitigate Infectious Disease Spread.” Plos One 15, no. 7 (2020). https://doi.org/10.1371/journal.pone.0235891. Dietrich, Watts L., James S. Bennett, Byron W. Jones, and Mohammad H. Hosni. “Laboratory Modeling of SARS-CoV-2 Exposure Reduction through Physically Distanced Seating in Aircraft Cabins using Bacteriophage Aerosol - November 2020.” MMWR - Morbidity and Mortality Weekly Report 70, no. 16 (April 23, 2021): 595-599. https://doi.org/10.15585/mmwr.mm7016e1. Milne, R. John, Camelia Delcea, and Liviu-Adrian Cotfas. “Airplane Boarding Methods that Reduce Risk from COVID-19.” Safety Science 134, (2021). https://doi.org/10.1016/j.ssci.2020.105061. Salari, Mostafa, R. J. Milne, Camelia Delcea, and Liviu-Adrian Cotfas. “Social Distancing in Airplane Seat Assignments for Passenger Groups,” Transportmetrica B: Transport Dynamics, 10:1 (2022): 1070-1098. https://doi.org/10.1080/21680566.2021.2007816. Tande, Aaron J. et al. “SARS-CoV-2 Testing Prior to International Airline Travel, December 2020-May 2021.” Mayo Clinic Proceedings 96, no. 11 (November 2021): 2856-2860. https://doi.org/10.1016/j.mayocp.2021.08.019.
Epidemiology/disease transmission	Freedman, David O. and Annelies Wilder-Smith. “In-Flight Transmission of SARS-CoV-2: A Review of the Attack Rates and Available Data on the Efficacy of Face Masks.” Journal of Travel Medicine 27, no. 8 (December 2020). https://doi.org/10.1093/jtm/taaa178. Hu, Maogui, Jinfeng Wang, Hui Lin, Corrine W. Ruktanonchai, Chengdong Xu, Bin Meng, Xin Zhang, et al. “Risk of SARS-CoV-2 Transmission among Air Passengers in China.” Clinical Infectious Diseases (2021). https://doi.org/10.1093/cid/ciab836. Yang, Wan, Subbiah Elankumaran, and Linsey C. Marr. “Concentrations and Size Distributions of Airborne Influenza A Viruses Measured Indoors at a Health Centre, a Day-Care Centre and on Aeroplanes.” Journal of the Royal Society, Interface 8, no. 61 (2011): 1176-1184. https://doi.org/10.1098/rsif.2010.0686.
Syntheses of existing research	Chu, Derek K., Elie A. Akl, Stephanie Duda, Kara Solo, Sally Yaacoub, and Holger J. Schünemann. “Physical Distancing, Face Masks, and Eye Protection to Prevent Person-to-Person Transmission of SARS-CoV-2 and COVID-19: A Systematic Review and Meta-analysis.” Lancet 395, no. 10242 (June 27, 2020): 1973-1987. https://doi.org/10.1016/S0140-6736(20)31142-9. Marcus, L. Assessment of Risks of SARS-CoV-2 Transmission during Air Travel and Non-Pharmaceutical Interventions to Reduce Risk, Phase One Report: Gate-to-Gate Travel Onboard Aircraft, Harvard T.H. Chan School of Public Health, 2020. ———. Assessment of Risks of SARS-CoV-2 Transmission during Air Travel and Non-Pharmaceutical Interventions to Reduce Risk, Phase Two Report: Curb-to-Curb Travel through Airports: Aviation Public Health Initiative, Aviation Public Health Initiative, Harvard T.H. Chan School of Public Health, 2021. Transportation, Research Board and National Academies of Sciences, Engineering, and Medicine. Infectious Disease Mitigation in Airports and on Aircraft, edited by Environmental Health & Engineering, Inc. Washington, DC: The National Academies Press, 2013. https://doi.org/10.17226/22512.

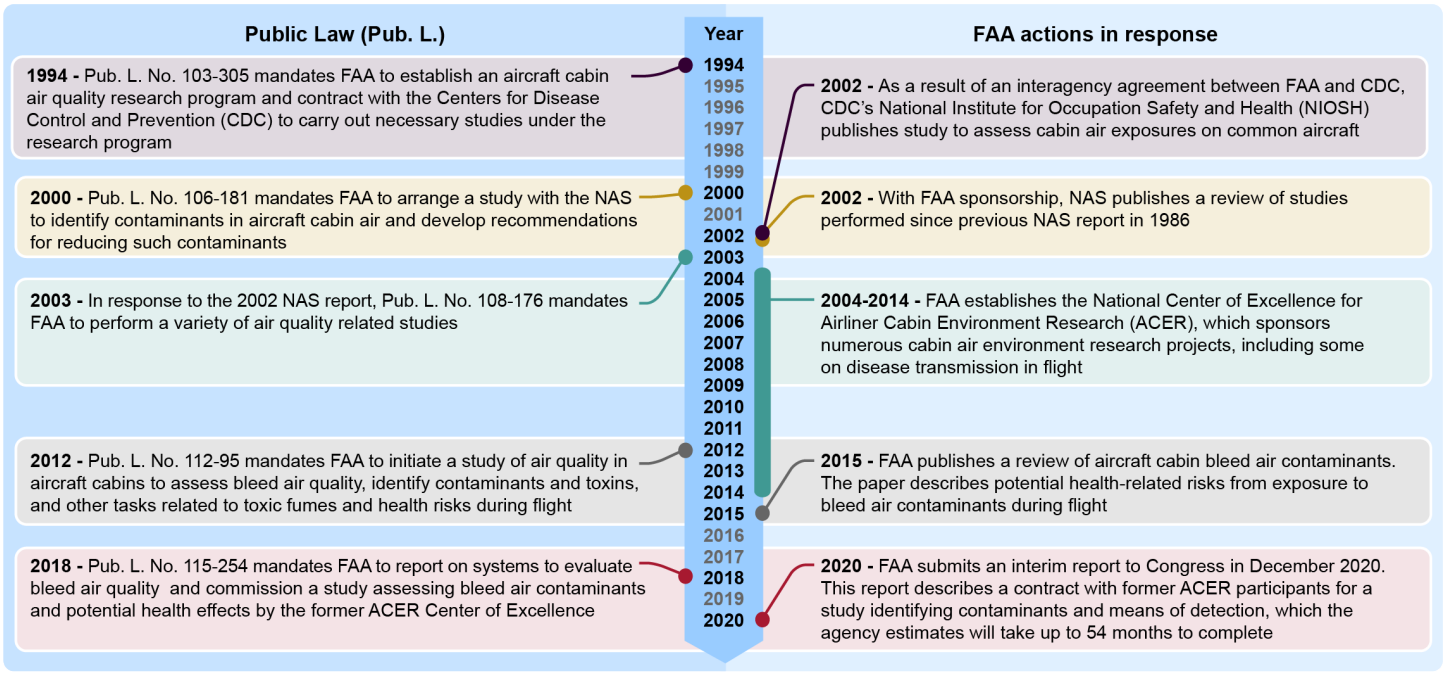
Selected research areas	Selected citations
Reports by Airliner Cabin Environment Research (ACER) Program Center of Excellence	Chen, Q., B. W. Jones, S. M. Loo, W. W. Nazaroff, R. A. Overfelt, J. D. Spengler, C. P. Weisel, and C. J. Weschler. Report to the FAA Airliner Cabin Environment: National Air Transportation Center of Excellence for Research in the Intermodal Transport Environment (RITE), 2010. Chen, Q., J. J. McDevitt, J. K. Gupta, B. W. Jones, S. Mazumdar, S. B. Poussou, and J. D. Spengler. Infectious Disease Transmission in Airliner Cabins: National Air Transportation Center of Excellence for Research in the Intermodal Transport Environment (RITE), 2012. Gale, William F., Hyacinth S. Gale, Jean Watson, Airliner Cabin Environment Research (ACER) Program. Field Evaluation of Whole Airliner Decontamination Technologies for Narrow-Body Aircraft, 2008. Gale, William F., Hyacinth S. Gale, Jean Watson, Airliner Cabin Environment Research (ACER) Program. Field Evaluation of Whole Airliner Decontamination Technologies - Wide-Body Aircraft with Dual-use Application for Railcars, 2008. McNeely, Eileen, John Spengler, and Jean Watson. Health Effects of Aircraft Cabin Pressure in Older and Vulnerable Passengers: National Air Transportation Center of Excellence for Research in the Intermodal Transport Environment (RITE), 2011.

Source: GAO analysis of literature related to research on communicable diseases in air travel. | GAO-22-104579

Appendix III: FAA Health and Safety Research Mandated by Statute

The Federal Aviation Administration (FAA) has undertaken research addressing health and safety in the past in response to statutory mandates. For example, several laws have been enacted requiring FAA to study cabin air quality and associated health effects. A selection of these laws and research work since 1994 is shown in figure 5.[1]

Figure 5: Federal Aviation Administration's (FAA) Responses to Statutory Mandates for Research on Cabin Air Quality and Health Effects (1994 through 2020)



Source: GAO analysis of Public Laws and FAA information. | GAO-22-104579

[1]FAA cabin air-quality research initiatives after 2014 focus more specifically on "bleed air" and potential contaminants. Bleed air is outside air that is drawn through jet engines into an aircraft cabin. For more information about bleed air, see FAA, Civil Aerospace Medical Institute, *Aircraft Cabin Bleed Air Contaminants: A Review* (Oklahoma City, OK: November 2015).

Appendix IV: GAO Contact and Staff Acknowledgments

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Staff Acknowledgments

In addition to the contact named above, Jean Cook (Assistant Director); Molly Laster (Analyst in Charge); Paul Aussendorf; Susan Bernstein; Karen Doran; Camilo Flores-Monckeberg; Geoffrey Hamilton; Hayden Huang; Dan Luo; Brittaini Maul; Jonathan Munetz; Mona Nichols Blake; Josh Ormond; Kelly Rubin; Pam Snedden; and Laurel Voloder made key contributions to this report.

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