

# **A study of COVID-19's Impact on the Aviation Industry**

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## **Abstract**

This report analyses the impact that the COVID-19 pandemic and its resulting travel bans have had on the aviation industry. It focuses on the effect on the UK with some global references or references to other countries/continents. Research on the severe economic and social impacts on the aviation and aerospace industries, both current and predicted, is also discussed. Data from March - June is used to compare and draw conclusions on the changes in flight numbers for different types of UK flights. The environmental impact of these changes in air travel is also explored, using research, satellite images, and statistics from the past few months, before discussing why changes are predicted to be short term by National Geographic, and how airlines can use environmental regulations to maintain demand post-COVID-19. Finally, the impact of COVID-19 on the aviation industry and its predicted recoveries is compared with the effects and recoveries of other significant events from the 21st century, including the Severe Acute Respiratory Syndrome (SARS) pandemic and the 9/11 terrorist attacks, by comparing data from these events and the current pandemic.

## **Introduction**

For this research project, I was asked to explore the title 'A study of COVID-19's impact on the Aviation Industry', and to include research on predicted recoveries, the impact on and recoveries of jobs in this industry, and the impact on the UK aerospace manufacturing industry and wider aviation operators. Before starting the report, I knew very little about the topic, so I conducted some brief preliminary research into the different types of flights upon the suggestion of my supervisor. I also completed the preparatory modules on research and data analysis which helped prepare me for writing the report. When creating my report outline, I decided to include research about the environmental aspect of the topic, as it was an area that I was particularly interested in. I also wanted to include research on other events which significantly impacted the aviation industry in the past, as I already knew a little about one of these events from studying the Ejayalljokul eruption in school and I was inspired by an existing report by Gössling, 2020 that discussed a similar subtopic (Pandemics, tourism, and global change: a rapid assessment of COVID-19).

In this report, I will first discuss the methods I used to complete my research. The main section of the report begins with a discussion of the effects of COVID-19 and its resulting travel bans on the aviation and tourism industry in the UK, before briefly comparing the impact on the aviation industry in Europe to the impact on the aviation industry in other continents. Then, I will examine two subtopics within this area. Firstly, how COVID-19's impact on aviation has affected the environment, with predictions on whether or not these environmental changes will be long term. Whilst several articles have analysed the impact of the lack of overall travel, I have not seen any report that focuses specifically on the impact of the reduction of air travel, so I wanted to discuss this in my report. Finally, I will compare the impact of COVID-19 on aviation with the impact on

aviation of other significant events of the 21st century, both viral outbreaks and otherwise, comparing the recovery of these events with various predicted possible recoveries of COVID-19's impact on the aviation industry.

## **Methods**

To answer the project question, I decided to make my report in the style of a literature review. I searched through the reports and articles provided on the VLE to find research relevant to my topic. I also used the search engines Google and Google Scholar to find relevant reports, news articles, and webpages. To make the graphs and tables, I used data from sources such as the Civil Aviation Authority (CAA). I chose to use the UK CAA's data, as it is from a renowned and unbiased organisation, unaffiliated with any businesses, and provides easily-accessed data tables for every month of the past few years. I then copied the data into a table on Google Sheets before using the program to turn the table into a graph, which I edited to make the information as clear and understandable as possible. The other graphs and satellite images were taken from the reports and articles I used and cited in my research. I was limited to articles and websites written in English and available for free online or in the Virtual Learning Environment (VLE). I tried to ensure that I used sources that were reliable by checking that they were written by professionals in the field and avoiding articles affiliated with a business. I avoided using publically-edited sites like Wikipedia whenever possible by instead trying to use scientific research papers and websites by reliable organisations as sources.

For the section of my report entitled 'How does the impact of COVID-19 on the aviation industry compare to the impact of other significant events from the 21st century?', I used data from online sources to make graphs on Google Sheets to draw visual comparisons on the scale and impact of each of the discussed outbreaks and events. As shown, the number of cases of COVID-19 and Swine flu are so much greater than that of the other outbreaks, I had to put these values onto a separate graph to avoid the other bars becoming too small to be visible - a demonstration of the vast scale of these two outbreaks, particularly COVID-19. The economic impact of each event was harder to compare on a graph, as it was difficult to find the same statistics for each event. I chose to use the value for the estimated global economic loss to the aviation industry for each event (using a recent estimate for COVID-19), as it allowed me to compare events which impacted different countries, rather than focusing just on the UK and thus misrepresenting the impact of an event that severely affected a different area of the world. However, this graph's comparisons will only be approximately correct, as some of the values differ in how they were calculated. I have explained these discrepancies under each graph to avoid presenting incorrect information. In addition, some events had to be omitted as I couldn't find the data I needed. I also used a graph from the International Air Transport Association (IATA, 2020b).

## **The effect of COVID-19 on the aviation industry in the UK with global comparisons**

## Introduction - COVID-19 and its Travel Restrictions

The pandemic caused by the coronavirus COVID-19 originated in Wuhan, China in December last year. Since then, it has spread to 213 countries and has now caused over 19 million cases and 731,727 deaths, as of the 9th of August (Worldometer, 2020). Its main symptoms are usually mild, including fever, a consistent cough, and loss of smell or taste (NHS, 2020) - but in around 1 in 5 cases, it can cause serious breathing difficulties, according to the World Health Organisation (WHO) (2020b). It is easily spread through droplets from infected persons when they are breathed in or transferred onto surfaces which are then touched by others (WHO, 2020). As a result of this rapidly spreading virus, governments all over the world have been forced to establish lockdown, social distancing measures, and travel restrictions to prevent the spread of the virus.

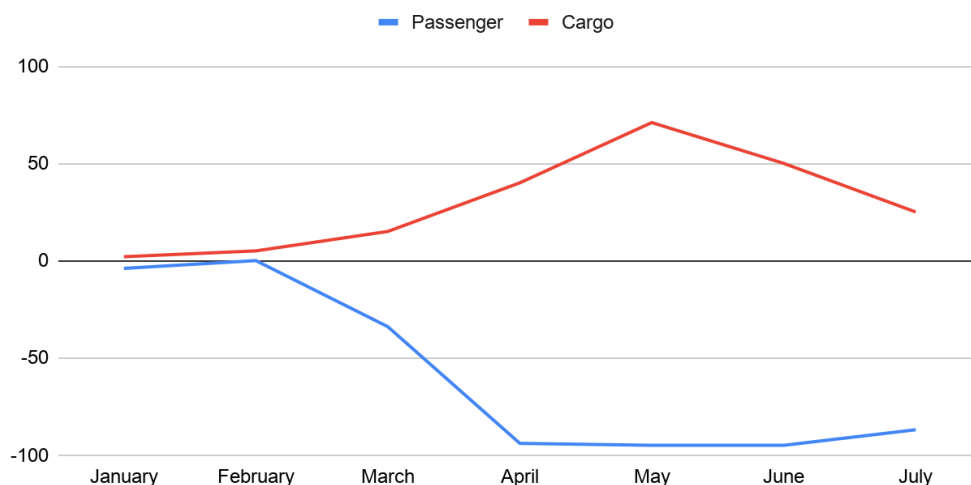
Most governments have placed restrictions on air travel due to COVID-19. An estimated 90% of the world's population now live in countries with some level of international travel restrictions, many of which also restrict internal movements (Gössling, S., 2020). On March 17, 2020, the UK government advised against all 'non-essential international travel' in a statement by the Foreign Secretary Dominic Raab (Gov.UK, 2020), and the European Union closed all its external borders for the first time in history (European Commission 2020, cited by Linka et al., 2020). Whilst some destinations assessed as no longer a risk to travellers were exempted from these restrictions on July 4th (Gov.UK, 2020), the impact of the travel ban has and will have a significant impact on the aviation industry. Without sufficient ticket sales, airports have been forced to ground their planes to reduce expenditure (Janiaud, A., 2020), resulting in the cancellation of both international and domestic flights as well as the decline of tours (Buisnesswire, 2020). The scale of COVID-19's negative impact can be seen in the vast decrease in flight numbers across the UK. Data from the UK Civil Aviation Authority (CAA) shows the total number of flights that started or ended in the UK from all of the UK's reporting airports dropped from 109,925 in March 2020 to 11,760 in April 2020 - 92.1% less than the number of flights in April 2019. The comparison of the flights that took place last year and this year also clearly shows the ban's impact - the total number of flights from reporting UK airports in May 2020 was 13,472, 91% less than the number of flights in May 2019, (CAA, 2020a).

## The impact on air transport movements and passenger numbers in the UK

Air transport movements encompass '(l)andings or take-offs of aircraft engaged on the transport of passengers, freight or mail on commercial terms' (CAA, 2020b). According to the UK CAAs data, the total number of air transport movements from/to all of the UK's reporting airports in May 2020 was 27,487 - 90% less than the 289,447 air movements reported in May 2019. As expected, this 90% decrease in air movements is mainly due to the considerable drop in passenger numbers due to the travel ban. The number of passengers in all UK reporting airports in May 2020 was 327,929, a substantial 99% less than the 26,794,086 passengers in May 2019. Similarly, April 2020 also had 99% fewer passengers than April 2019, and June 2020 had 98% fewer passengers than June 2019 (CAA, 2020a). The graph below uses the CAA data of the air transport movements to/from the UK for each available month, and clearly shows the

dramatic decrease in passenger air transport movements since the travel restrictions established on the 17th of March. As the graph shows, the relaxation of UK travel restrictions on the 4th of July has had a small impact on passenger air transport movements - whilst both May and June 2020 saw a percentage change of -95% in passenger air transport movements, July saw an -87% change, as compared with the same month in 2019.

Percentage Change in Air Transport Movements from All Reporting UK Airports When Compared to the Same Month Last Year



**Fig. 1 - Graph showing the percentage change in passenger and cargo air transport movements from all reporting UK airports in 2020 as compared to the same month in 2019 (Data from the CAA, 2020).**

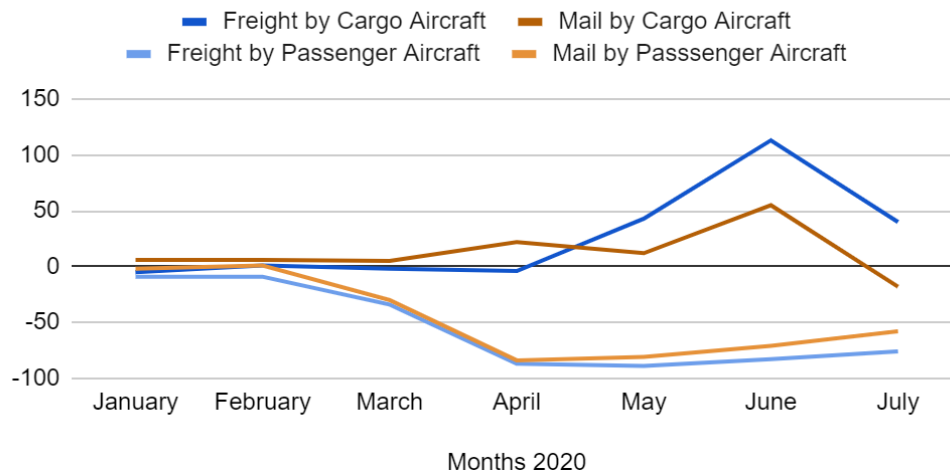
### The impact on freight and mail transport in the UK

As shown in the graph above, since the start of the ban on all non-essential passenger travel on the 17th of March in the UK, passenger air transport movements have decreased significantly, whereas cargo air transport movements have shown a less dramatic increase. However, looking at the CAA data for the freight and mail of each airport over the past few months as compared to the same months the previous year, one can see that the effect of COVID-19 on freight and transport has been more varied than the consistent decrease in passenger transport across all UK airports. As the graph below shows, freight transport via cargo aircraft has shown a general increase since March. However, the data for each individual airport is very varied, with some airports showing large increases, such as Heathrow's increase of 663% in May, and some airports showing large decreases, such as Birmingham's decrease of 61% in the same month, as compared to May 2019 (CAA, 2020a). The UK government classifies both international and domestic freight transport as an essential activity, meaning it is not subject to the same restrictions as non-essential passenger travel (Gov.UK, 2020) and so how each airport responds to COVID-19 in terms of freight transport via cargo may vary. The large increases seen in Heathrow's monthly freight transport via cargo aircraft could be explained by the reopening of the Shanghai to Heathrow passenger route to allow PPE and ventilators to be transported to London (IAG Cargo, 2020).

Contrastingly, freight transport by passenger aircraft has decreased significantly and consistently, as shown on the graph. For example, the total weight of freight transported by passenger aircraft in all reporting UK airports in May 2020 was 89% lower than that of May 2019 (CAA, 2020a). This decrease may negatively affect UK trading. For instance, Heathrow airport plays a significant role in the UK trading position - 40% of all non-EU imports come into the UK via Heathrow airport, mainly in the hold of passenger aircraft, suggesting that the decrease in the transport of freight by passenger aircraft could cause the cost of goods to go up for UK businesses (Bailey, G., 2020). In response of COVID-19's impact, the International Air Transport Association (IATA) has been supporting airlines in using passenger aircraft to transport cargo without passengers onboard to "enhance shipping connectivity options" (IATA, 2020a). It is important to consider that the data tables made by the CAA may not be a reliable indicator of the impact on freight transport, as several of the listed airports do not have data for either 2020 or 2019, so a percentage change cannot be calculated. Also, some smaller airports transport only a few tonnes of freight each month, meaning that a decrease of a small number of tonnes between 2019 and 2020 resulted in large percentage changes. For example, Kirkwall airport transported 3 tonnes of freight via passenger aircraft in May 2019 and 1 ton in May 2020, a decrease of only 2 tonnes but a percentage change of -67%, which will impact the overall percentage change for all UK airports (CAA, 2020b).

Mail transport shows similar patterns to freight transport. Firstly, there is a consistent overall percentage decrease in tonnes of mail transported by passenger aircraft - for example, the transport of mail via passenger aircraft by all reporting UK airports in May 2020 is 81% lower than that of May 2019. Secondly, mail transport is also considered essential, so it is not under the same restrictions as non-essential passenger travel, resulting in the lack of a consistent significant decrease when transported by cargo aircraft. Like freight transport, the percentage change in both the transport of mail by cargo aircraft is very varied across the different airports, and the overall increases shown are mainly due to dramatic percentage increases shown by a few large airports. For example, in May 2020, Inverness' airport showed an increase of 361% for mail by cargo aircraft, whilst several other airports showed less significant changes, such as Luton airport's decrease of 11%. Notably, Heathrow airport showed a dramatic increase in the transport of mail by cargo aircraft as well as freight in May 2020, going from 104 tonnes in May 2019 to 2,479 tonnes - a percentage change of 2,284% (CAA, 2020a). The graph below shows how the increase in the transport of mail via cargo aircraft is smaller and more varied than the increase in freight transport via cargo aircraft, which may be a reflection of the recently increased transport of PPE as freight.

## Percentage Change From the Same Month in 2019 of Tonnes of Freight/Mail Transported Per Month



**Fig. 2 - Graph showing the percentage change in the tonnes of freight and mail transported from all reporting UK airports each month in 2020 by cargo and passenger aircraft, as compared to the same month in 2019 (Data from the CAA, 2020).**

### The impact on general, business, and other types of non-commercial aviation

Other types of flight in the UK have also shown a decrease compared to 2019. The number of military aircraft movements by all UK reporting airports in May 2020 have shown a percentage change of -43% compared with May 2019. The percentage change of other general aviation (GA) flights from reporting airports also all show a decrease from May 2019: Test and training flights decreased by 77%, flights by Aeroclub members by 95%, private flights by 82%, official flights by 16%, and other flights by air transport operators by 70% (CAA, 2020a). Business aviation, a sector which generates nearly €90 billion in revenue every year and employs more than 370,000 people, saw a decrease of 83% in May 2020 compared to May 2019. Business aviation operators have experienced severe reductions in charter flights, the grounding of fleets, and the need for insurance premiums and aircraft sales to offset expenses as a result of travel restrictions on non-essential travel (Taylor, 2020). However, one sector of business aviation has not been affected - medical flights. According to the European Business Aviation Association (EBAA), the average business aviation operator in Europe will execute 70 medical flights per day, an essential activity for the safety of the public (EBAA, 2020).

### The social impact on the UK aviation industry

The impact on the lives and work of aviation professionals, an industry that supports around 330,000 jobs (Huw Merriman, 2020, cited by Bailey, 2020), has also been significant, with workers in all areas of the industry being furloughed or made redundant (Royal Aeronautical Society, May 2020). Airports all over the world, including British Airways, have asked their

employees to take voluntary leave (Tiwari et al., 2020), and in Europe, nearly 1 out of 5 pilots are on a 'precarious contract' (Royal Aeronautical Society, May 2020). The World Travel and Tourism Council has warned that 50 million jobs in the tourism and global travel industry are at risk of being cut worldwide (World Economic Forum, 2020, cited by Nicola et al., 2020). There have also been many additional precautions that have had to be taken by flight staff. More recently, many airports that have since been working on a 'skeleton service' of flights are now slowly increasing the number of flights they will be running per day (Scotto di Santolo, 2020). For example, Ryanair has returned to 40% of its previous flight schedule on 3rd July, going from 30 to 1000 flights per day - however, they predict that at least half of the seats will be empty. Ryanair plans to disinfect their aircraft interiors every night and has banned cash sales on board to reduce risk of transmission. They have also put in place passenger requirements such as the mandatory wearing of face masks and filling out a form detailing their travel plans (Scotto di Santolo, 2020).

### The economic impact of the UK's aviation and aerospace industries

Many organisations and researchers have made predictions on the negative economic impact of the changes to flights. The World Travel and Tourism Council warned that international travel could be adversely impacted by up to 25% this year due to the restrictions on passenger flights - the equivalent of 3 months of travel lost. The council predicts that it may take up to 10 months for the tourism sector to return to its normal levels (World Travel and Tourism Council, 2020, cited by World Economic Forum, 2020). To prevent a widespread shutdown, UK airlines have called for a £7.5bn emergency bailout (The Guardian, 2020b, cited by Nicola et al., 2020). According to hypothetical scenarios from the report 'Estimating and projecting air passenger traffic during the COVID-19 coronavirus outbreak and its socio-economic impact' (Maria Iacus et al., 2020), the impact of aviation losses could negatively reduce worldwide GDP by 0.02% - 0.12%, with losses as high as 1.41–1.67% estimated for the end of 2020.

The aerospace industry supplies hardware for commercial air travel as well as for military flights and missiles, GA operations, space flights, and unmanned aircraft systems, referred to as drones (Investopedia, 2020). It supports 120,000 jobs in the UK (Gov.uk, 2020Feb), of which 25% are engineers and scientists involved in the research and development sector (Investopedia, 2020). However, Deloitte, 2020, explains how COVID-19 has forced many workers to take leave and slowed production. For example, Airbus' production rates have dropped by 30%, has 40% of its employees in its commercial aircraft sector on furlough, and is predicted to cut 1,700 jobs in the UK alone (Skates, 2020). Demand for commercial aircraft and spare parts has decreased as air travel has dropped and customers defer deliveries, which may lead to the need for financial support (Deloitte, 2020). Contrastingly, the short and mid-term demand for military aircraft and missiles is less impacted due to the continued need for these products and their pre-established budgets, but in the long-term, demand may slowly decrease as governments are forced to reduce expenditure due to the economic impact of COVID-19 (Deloitte, 2020). To support the aerospace industry, Ken Skates, the Minister for Economy and Transport, proposed ideas such as encouraging internal flights to increase demand for

commercial aircraft manufacture, and incentivising airlines to carry out their Maintenance, Repair, and Overhaul (MRO) in the UK to increase demand for MRO staff (Skates, 2020).

The Space industry also hasn't avoided the impact of COVID-19. In Europe, politicians warn that the industry could be negatively affected by up to €1bn (Silva and Gill, 2020), and several rocket launches have been delayed (Seraphim Capital, 2020). Workers within the Space industry, of which there are 230,000 in Europe alone, have been affected by social distancing measures much like most jobs - for example, the European Space Operations Centre has been operating on minimal staff (Silva and Gill, 2020).

### The impact in Europe compared to other continents

The World Health Organization declared Europe the epicentre of the pandemic on 13th March, having had more cases and deaths than the rest of the world combined (World Health Organization, 2020, cited by Linka et al., 2020). Since then, Latin America has been declared the new epicentre, with more than a million cases (Broto, 2020). By March 22, 2020, the average passenger air travel in Europe was cut in half (World Health Organization, 2020, cited by Linka et al., 2020), and airport management companies in Europe are expected to incur a loss of \$15.4 billion due to the pandemic (Buisnesswire, 2020). The European Tourism manifesto alliance has highlighted the need for urgent measures including emergency loans, state aid (Hotel-online, 2020, cited by Nicola et al., 2020), and the launch of an unemployment reinsurance scheme (Gaál, 2020, cited by Nicola et al., 2020). Despite this, the tourism industry in Asia is expected to be the worst affected, with around 30 million tourism jobs predicted to be lost in Asia out of the 50 million predicted worldwide. Comparatively, Europe has been predicted a loss of 7 million, and the Americas 5 million (World Travel and Tourism Council, 2020, cited by World Economic Forum, 2020). However, it is important to consider that the impact on the aviation industry may have an even greater effect on countries that rely more heavily on it. For example, in Africa, tourism is one of the countries' main sources of income, with its air transport industry contributing up to \$55.8 billion to its GDP and supporting an estimated 6.2 million jobs, according to the International Air Transport Association (Ighobor, 2020). Its tourism and travel sectors are predicted to potentially lose 'at least \$50 billion and at least two million direct and indirect jobs' (Ighobor, 2020). Contrastingly, the Australian Airports Association (AAA) Australia's major airports may lose on the upwards of \$500 million in aeronautical revenue alone this year, compared to 2019 (Simon Bourke, cited by International Airport Review, 2020).

### **Environmental impact of the changes to overall flight patterns caused by the outbreak**

COVID-19's negative impact on air travel has had some positive side effects for the environment. The aviation industry is a significant contributor to greenhouse gas emissions - if it were a country, it would be the sixth-largest contributor in the world, between Japan and Germany (Centre for Biological Diversity, 2020). Unlike other methods of transport, aeroplanes emit a range of greenhouse gases directly into the higher levels of the atmosphere, making them particularly harmful to the environment (The Conversation, 2020). They also generate large amounts of carbon dioxide, one of the most impactful greenhouse gases, by often relying

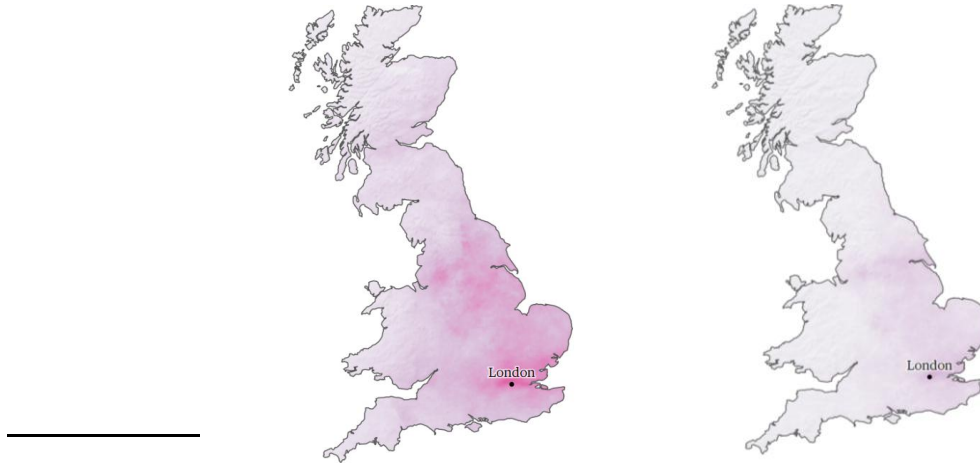


on carbon-rich fossil fuels to run their engines. (Civil Aviation Authority, 2015). However, global travel restrictions and lockdown regulations have reduced both air travel and road travel, which in turn decreases the demand for oil (Zowalaty, Young, and Järhult, 2020). This overall decrease in transport and oil usage has led to a decrease in both air and noise pollution.

### Positive effects on the environment

One effect of the COVID-19 travel restrictions is that fewer tourists are visiting popular seaside locations - for example, the beaches of Barcelona Salinas, causing them to develop a cleaner appearance and clearer waters (Zambrano-Monserrate et al., 2020). The canals of the usually popular tourist destination Venice have become much clearer due to the reduced number of boats (Crossley, 2020) affected by the lack of canal tours after the EU closed its borders on the 17th March (Gov.UK, 2020). The dramatic global reduction in passenger flight numbers has also impacted. It has contributed towards a global drop in greenhouse gas emissions due to its aforementioned large contribution to emissions, particularly in the emission of carbon dioxide (CO<sub>2</sub>), of which it is responsible for 2% and rising of all global carbon dioxide emissions (The Conversation, 2020). Daily global carbon emissions were shown to be down by 17% in early April this year (National Geographic, 2020), and at their peak, the maximum daily decrease in CO<sub>2</sub> emissions for individual countries averaged to 26% (Le Quéré et al, 2020). Average levels of air pollution have dropped in major cities around the world - in New York, air pollution levels have dropped by almost 50% compared to this time last year (Saadata, Rawtani, and Hussain, 2020). In the UK, the total change in carbon emissions is an estimated 18 million tons, with an estimated 98 million decrease in India, 12 million in Europe, and 242 million in China (Earth.org, 2020). Reducing global air pollution level is particularly important in consideration of the pandemic, as air pollutants 'inflammate and lower immunity' (Paul Monks, cited by The Guardian, 2020d) and can be a vector for pathogens. The World Health Organisation is currently investigating whether or not these particles can be a vector for Covid-19 (The Guardian, 2020d).

However, the travel restrictions' impact isn't the only factor reducing air pollution during this time. The requirement for more people to stay at or work from home and the resulting reduction in road travel has also had an impact on the environment. One pollutant mainly produced by traffic is nitrogen dioxide (NO<sub>2</sub>), which potentially causes bronchial and respiratory problems (Muhammad et al., 2020). Both the reduction of travel and oil demand may have reduced NO<sub>2</sub> emissions by up to 30%, according to evidence from NASA (National Aeronautics and Space Administration) and ESA (European Space Agency) (cited by Muhammad et al., 2020). This decline in emissions initially occurred near Wuhan and eventually spread (Wang and Su, 2020), with NO<sub>2</sub> emissions now dropping all over Europe and the UK, as visually represented in the images below (The Guardian, 2020). Additionally, the closure of factories and power plants have caused coal usage to decrease - for example, China's largest power plants have shown a 40% drop since the last three months of 2019 (Saadat, Rawtani, and Hussain, 2020).



**Fig. 3 -**

**Visual representation of NO<sub>2</sub> levels in the UK  
2019 (left) and 2020 (right) (from The Guardian, 2020a)**

### Negative effects on the environment

Whilst there was an initial reduction of 17% in April 2020 from April 2019, data from 11th June shows that global daily carbon dioxide emissions are only 5% lower than the same point in 2019, even with normal activity not yet fully resumed (National Geographic, 2020), and the average drop in emissions for the whole of 2020 is estimated to be only 4-7% lower than 2019 (The Guardian, 2020d). There are many possible reasons for why the recent change and estimated overall difference is not as large as expected. As previously mentioned, whilst the number of passenger flights have decreased significantly, freight and mail transport from UK airports have shown little change, with some airports greatly increasing their freight and mail transport (Civil Aviation Authority, 2020), resulting in more CO<sub>2</sub> emissions. In addition, with many airlines continuing to transport freight in the cargo section of now empty passenger planes (Horton, 2020), or capping passenger flights at 50%-60% capacity as the travel ban eases (Reuters, 2020), the current usage of fossil fuels by airlines could be considered inefficient or wasteful. According to May readings from the Mauna Loa observatory, the atmosphere's CO<sub>2</sub> concentration recently reached 417.2 parts per million, 2.4ppm higher than the peak of 414.8ppm in 2019 (The Guardian, 2020d). Oceanography professor Ralph Keeling explains that as the CO<sub>2</sub> levels in the atmosphere keep piling up as emissions continue, the effect of COVID-19 has 'slowed emissions, but not enough to show up perceptibly at Mauna Loa' (Ralph Keeling, cited by The Guardian, 2020d).

The travel ban's impact on tourism has also had some negative effects. Recently, optimistic images of wild animals such as deer spotted in urban areas due to the lull in human activity have been spreading on social media (Davidson, 2020, cited by Crossley, 2020). However, some of these creatures have been forced to venture into cities in search of food due to the lack of tourists who would ordinarily supply them with food - for example, in Nara, Japan, herds of

sika deer which would normally be fed 'deer crackers' by tourists visiting their park have left to scavenge in cities (Crossley, 2020).

Other indirect impacts of COVID-19 have also had some negative environmental effects. For example, domestic waste generation has increased for a number of reasons - recycling programs have been temporarily banned in many areas, reusable shopping bags and coffee cups that used to be promoted are now advised against in favour of disposable single-use items, online food and its accompanying disposable packaging ordering has increased, and an increase in medical waste from hospitals from PPE disposal (Zambrano-Monserrate et al., 2020). One example of this is in Wuhan, China, where 200 tons of clinical trash was produced on 24th February alone - four times the amount that the city can incinerate per day (Saadata, Rawtani, and Hussain, 2020). Additionally, in one case, the economic impact of the pandemic has caused provincial officials in China to allow the construction of coal-fired power plants for an economic boost, which will have long-term negative effects as these infrastructures are likely to be used for many years (National Geographic, 2020).

#### Will these effects have a significant impact?

An article by National Geographic explained, perhaps pessimistically, that the decrease in greenhouse gas emissions is likely only temporary, as individuals and businesses will likely be eager to resume their regular activities as soon as possible. It discussed the risk of the same outcome of the 2007-2008 financial crisis occurring, where emissions dropped during the crisis only to bounce back afterwards (Corinne Le Quéré, cited by National Geographic, 2020), and how the methods of transport, energy supplying, ect., have not changed during the lockdown, so there is little evidence to suggest there will be a continued decrease in greenhouse gas emissions once daily life returns to normal (National Geographic, 2020). Similarly, Zambrano-Monserrate et al. (2020) concluded that for significant impact on the climate crisis to be made, aviation companies would have to make long term changes. The article 'Aviation's climate commitments: Clean skies from COVID-19 and beyond' (Mullaney and Baronett, 2020) more optimistically suggests that the pandemic has demonstrated the vulnerability of the airline industry against decreases in demand, which may lead more companies to work against the future's 'biggest long-term risk to demand' - consumers reducing their air travel due to the negative environmental effects of air travel. It discusses how working towards a decarbonised system using techniques such as carbon offsets and investing in low carbon biofuels could help airlines maintain demand (Mullaney and Baronett, 2020). A survey conducted by Publicis Sapient in May suggests that this method would be effective - of the respondents, 66% said they would be more likely to purchase from an airline that has increased its sustainability efforts (Publicis Sapient and Skift, 2020). Many companies have already shown signs of working to meet their customer needs, including the need for decarbonisation, even during the pandemic, in order to maintain their demand in the long term (Mullaney and Baronett, 2020). Notably, the Director of Planning and Environmental Affairs for the San Diego County Regional Airport Authority stated that it is 'this legacy of sustainability leadership – economic, social, and environmental – that will help us rebound from COVID-19 more quickly and successfully' (Reed, 2020, cited by Mullaney and Baronett, 2020). These factors could further suggest that airline

companies may take increased action towards sustainability after the crisis to prevent further economic loss in the future. However, it is important to ensure that these actions taken are effective and harmless - the aforementioned carbon offsets method used by some airlines, for example, have often been shown to be ineffective in reducing emissions, and often concentrate pollution in low-income communities or involve projects which displace Indigenous communities abroad (Centre for Biological Diversity, 2020). Whilst work towards sustainability by airlines after the pandemic is important for both their economy and the environment, I believe it is clear that any solution must be genuine and universally beneficial, rather than simply an appeal to customers.

Another important factor to consider is the public's future behaviour patterns. As the report 'Ecological grief generates desire for environmental healing in tourism after COVID-19' states, 'climate-related concerns about the ethics of flying to holiday destinations have been answered by COVID-19's abrupt cessation of almost all non-essential air travel' (Crossley, 2020) - the travel ban may have had a generally positive impact on the environment, but not by individual's own choices, so it is hard to know how peoples' attitudes may change after the pandemic. It has been suggested that the lockdown period may have changed consumers' opinions on the necessity of some of their luxuries such as holidays which could potentially have long-term effects of airport sales and thus greenhouse gas emissions, but there is also the chance of a resurgence in sales once lockdown ends and the fears and risks surrounding COVID-19 subside (Trembath and Wang, 2020 cited by Crossley, 2020). The pandemic's effects including lockdown and the travel ban may have enlightened more people to the shared idea of making sacrifices now to prevent suffering in the future also seen in the climate movement (Trembath and Wang, 2020 cited by Crossley, 2020), and has proven by example that reducing greenhouse gas emissions and other negative influences on the environment can quickly result in positive effects and outcomes for wildlife and air quality (Zowalaty, Young, and Järhult, 2020), as discussed above. This theory may be supported by the survey conducted by Publicis Sapient, where 58% of the respondents said that they are thinking more about the environment and sustainability now than before the pandemic began (Publicis Sapient and Skift, 2020). However, this survey may not be considered legitimate evidence, as it is not a large majority, and 75% of the respondents to the survey were aged 44 and under, suggesting the result does not accurately represent the older public's views. On the other hand, lockdown has prevented climate change protests such as the Earth Day Climate Strike which was due to occur in April from taking place on the streets as normal (Earth Day Strikes, 2020; Hockenos, 2020, cited by Crossley, 2020). Crossley (2020) suggests that due to the cancellations of these events, the climate change movement has been less prevalent in favour of the more pressing coronavirus crisis, which could potentially make it less of a concern in people's minds, leading to negative consequences for the environment once lockdown ends.

**How does the impact of COVID-19 on the aviation industry compare to the impact of other significant events from the 21st century?**

## Comparing COVID-19's impact on air travel to the impact of previous significant disease outbreaks of the 21st century

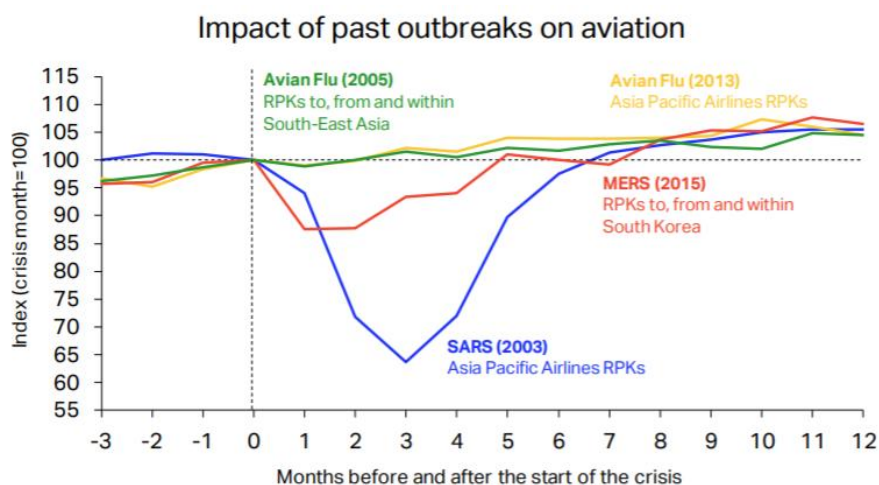
Whilst only twenty years into the 21st century, we have already seen several deadly infectious diseases - the Severe Acute Respiratory Syndrome (SARS) pandemic in 2002/3, the Avian influenza outbreak and Swine flu pandemic in 2009, the Middle East Respiratory Syndrome (MERS) outbreak in 2015, and the Ebola outbreak in 2013/16 - all before COVID-19 was declared a pandemic in March 2020 by the World Health Organisation. The article 'Pandemics, tourism and global change: a rapid assessment of COVID-19' (Gössling, Scott, and Hall, 2020) discusses these pandemics, explaining how the main reasons for the increased likelihood of pandemics in this century as compared to the 3 pandemics that took place in the 20th century include rapid population growth, increase in global transport, and lifestyle changes such as the increase in industrial food production. These pandemics have all had varying levels of impact on the aviation industry, particularly in the tourism sector. I will be looking at each of the above outbreaks and pandemics in detail, aside from the Avian influenza outbreak (H5N1). Whilst this virus was expected to, and still potentially could, develop into a pandemic, so far its impact has remained relatively small, with no new cases detected since February 2017 (Branswell, 2019).

The impact of COVID-19 on the aviation industry is more easily comparable with the impact of recent pandemics from the 21st century on the aviation industry due to how the industry and the world have changed over time. An article by Gavi (2020) explains how the three pandemics that occurred in the 20th century were not met with as strict restrictions surrounding social distancing, travel bans, and lockdowns as the outbreaks that occurred in the 21st century, and the amount of people travelling by flight has increased exponentially - the 310 million travelling by flight in 1970 had grown to 1.6 billion people by 2002. However, as the article points out, is worth noting that the scale of the COVID-19 pandemic is actually closer to the Avian flu pandemic in 1957-1958 and the Hong Kong flu pandemic of 1968-1970, which caused an estimated 1 million and 1.1 million deaths respectively (Gavi, 2020).

### **SARS**

SARS was the first deadly infectious disease of the 21st century, originating in China, 2003 with most cases in Asia and some in Canada (Gössling, Scott, and Hall, 2020). Like COVID-19, it was caused by a coronavirus, transmitted by respiratory droplets, and spread around the world partly through international air travel (Whitworth, 2020). However, whilst SARS caused more than 8000 cases and 774 deaths (Whitworth, 2020), COVID-19 has so far caused a significantly greater 19 million cases and 731,727 deaths (as of the 9th August, 2020) (Worldometer, 2020). To prevent the spread of SARS, the WHO issued a general travel advisory in March 2003 which led to a variety of travel bans, including border closures in the most affected areas and 110 countries issuing travel bans on tourists from these areas (McKercher and Chon, 2004). In Hong Kong, airports had to cancel flights in mid-March as visitor arrivals dropped by 10.4% compared to arrivals from the previous year, and a notable -77% difference was seen in arrivals between March and April (Siu and Wong, 2004). Whilst arrivals showed a dramatic decrease, the numbers of residential flights via airports only dropped by around 26% at most in April (Siu and

Wong, 2004), whereas due to the more restrictive travel bans issued to stop the spread of COVID-19, the decrease in domestic terminal passenger traffic reached -99% in April and May in all reporting UK airports (Civil Aviation Authority, 2020). However, the restrictions put in place for SARS had a devastating impact on Asia's tourism industry, with the most severely affected areas in China, Hong Kong, Singapore, and Vietnam losing 3 million jobs in this industry and \$20 billion in GDP (McKercher and Chon, 2004).



**Fig 4 - Graph showing the impact of previous pandemics and outbreaks on Revenue Passenger Kilometres (RPKs) in the stated regions (from IATA, 2020b).**

## Swine Flu

The novel influenza A (H1N1) virus, also known as Swine flu, was first detected in the US in Spring 2009 (Centres for Disease Control and Prevention (CDC), 2019), not long before the start of the 2009 financial crisis (see below). Whilst the WHO reported 18,500 confirmed deaths, more recent estimates suggest that between 123,000 and 203,000 people died as a result of the virus globally (Gavi, 2020). The graph below uses the average of these two numbers, a value 500 thousand fewer deaths than the current number of deaths for COVID-19. The virus spread to Canada and Mexico, before eventually more than 70 reported cases of the virus (CDC, 2010), including the United Kingdom (Wikipedia, 2020). As the WHO increased the pandemic's alert phase, recommendations were issued by the CDC for all US citizens to avoid non-essential travel to Mexico on the 27th April (CDC, 2010). Whilst some countries screened visiting travellers (Bajardi et al., 2011) or temporarily suspended certain flights, such as China suspending flights from Mexico to Shanghai on the 2nd May (Global Times, 2009), Swine flu's travel recommendations and restrictions were minimal in comparison to the complete ban on all

non-essential travel put in place for COVID-19. As with the Avian flu infection, the WHO decided against travel recommendations, concluding that they were ineffective against containing the outbreak (WHO, 2009, cited by Chung, 2015). However, the reduction in passenger demand as a result of the pandemic still had a negative impact on airlines as early as March 2009, where passenger demand fell by over 11% compared to March 2008, according to IATA data, with airlines in the Asia-Pacific leading the fall, followed by North America, then Europe, whilst airlines in the Middle East contrastingly showed a small increase in demand (Livemint, 2009). The article 'Impact of pandemic control over airport economics: Reconciling public health with airport business through a streamlined approach in pandemic control' (Chung, 2015) explains how whilst Swine flu was more difficult to screen due to its long incubation period and lack of symptoms showing in its early stages, the economic impact the H1N1 pandemic had on the aviation industry was much smaller than SARS', and by extension COVID-19's, impact, with the HKIA and SCA airports showing a mere -7.88% and -4.12% decrease in passenger air traffic during the March to May 2009 post-implementation period. Looking at the CAA data for passenger flights from the past several months, we can clearly see how much more of an impact COVID-19 has on passenger traffic, with every UK airline showing vast percentage decreases in the 40s to 90s when compared to the same month in 2019 as a result of the stricter regulations (CAA, 2020). In September 2009, four vaccines for the H1N1 virus were approved, with a fifth approved two months later, leading case numbers to gradually decline over the next several months (Centres for Disease Control and Prevention, 2010).

## **MERS**

Like COVID-19 and SARS, the MERS pandemic was caused by a coronavirus (Zumla, Hui, and Perlman, 2015). The first cases occurred in Saudi Arabia in 2012, before the virus spread to other areas in the Middle East, Asia, Europe, and the USA. Since 2012, 27 have reported cases of MERS, but 80% of all MERS cases have occurred in Saudi Arabia. As shown on the graph below, the impact of MERS is closer in scale to the SARS pandemic, with only 2,519 cases in total (WHO EMRO (Eastern Mediterranean Regional Office), 2020). The second outbreak of MERS occurred in South Korea, in June 2015 to September 2015 (Hepher, 2015). South Korea's tourism industry was severely affected, with a loss of 1,968,765 tourists and 3.1 billion USD in receipts during the period from June 2015 to September 2015. (Choe, Wang, Song, 2020). It caused a 12% decline in monthly RPKs to, from and within South Korea in the first month of the outbreak (Iacus et al., 2020). Whilst the impact was devastating for South Korea,

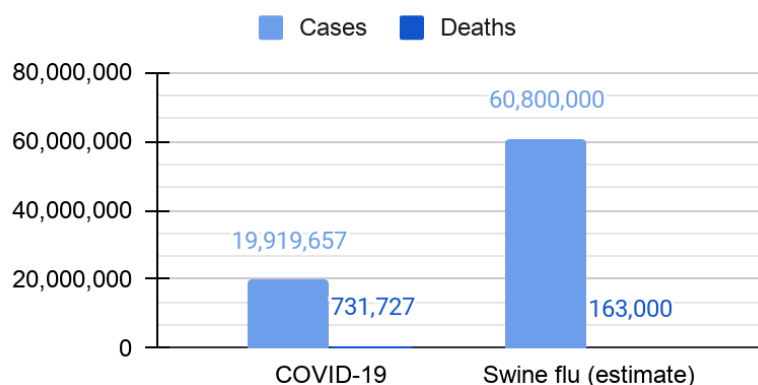
comparatively, COVID-19 has shown a more global and extreme impact, with an estimated \$26.1bn revenue loss for the UK's aviation industry alone (IATA, 2020c). After two months, air traffic numbers began to recover, returning to pre-outbreak levels after 6 months (Iacus et al., 2020), unlike the current pandemic's situation, where air traffic numbers have been consistently extremely decreased for at least three months due to the dramatic drop in passenger flights in April, May, and June by 94, 95%, and 95% respectively (CAA, 2020).

## **Ebola**

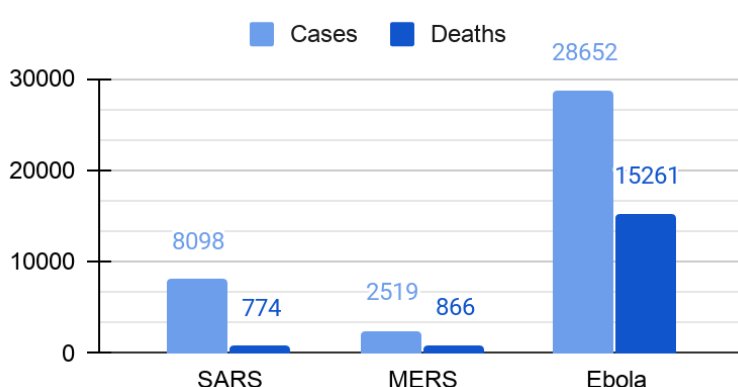
The Ebola outbreak started in December 2013, in Guinea, Africa, before spreading to several neighbouring countries in West Africa by July 2014 (Barlay, Stewart, and Pate, 2016). It eventually spread to other countries including the US, where there were 4 cases total, and Spain, Italy, and the UK, where 1 case was recorded in each country (CDC, 2019). As shown on the graph, its 28,652 total cases (CDC, 2019) were much higher than the number of cases of MERS or SARS, but much lower than the 19 million COVID-19 cases (as of the 9th August). However, the death rate of Ebola was much higher than that of COVID-19 - nearly one in every two Ebola victims died from the virus (Cederholm, 2014). Whilst no travel bans were issued by the WHO, who advised against issuing travel restrictions (The Guardian, 2014a), some individual countries placed regulations of their own upon travellers from Guinea, Liberia, and Sierra Leone, where the majority of Ebola cases occurred (CDC, 2019). In Canada, visas were denied to applicants from these three countries (Omoleke, Mohammed, and Saidu, 2016); In the US, passengers flying from affected countries in West Africa were required to fly via airports with screening in place (The Guardian, 2014b); and Senegal closed its borders to Guinea (The Guardian, 2014a). In the summer of 2014, 216, or 37%, of the 590 monthly flights scheduled to these three countries were cancelled (OAG, 2014 cited by The Guardian, 2014a). Whilst the travel restrictions were less strict and global than COVID-19, the tour and flight cancellations due to the Ebola virus had a significant impact on the aviation and tourism industry in Africa, with many airlines shutting down or reducing operations, and 13 million invested by governments to contain the spread of the first 20 cases in Nigeria alone (Omoleke, Mohammed, and Saidu, 2016).



## Cases and Deaths



## Cases and Deaths



**Fig. 5 and 6 - Graphs showing the number of deaths and cases caused by each virus (Sources: Wilder-Smith, 2005; WHO, 2020; CDC, 2019a; Worldometer, 2020; CDC, 2019b)**

### Comparing COVID-19's impact on air travel to the impact of other significant events of the 21st century

Pandemics and epidemics are not the only events that have affected air travel on a large scale this century. Whilst the risk of transmission of epidemics and pandemics often cause a decrease in passenger air travel due to a reduction in demand or travel bans, but little decrease in cargo air transport, travel bans and demand reduction caused by other events such as terror attacks will often affect all flight types.

#### **The 9/11 Terrorist Attacks**

The 9/11 terrorist attacks that took place on 11th September 2001 and caused the deaths of nearly 3000 people resulted in the closure of US airspace until 13th September, two days later (Bergen, 2020). This closure ceased all US and Canada flight apart from military, medical, police, and a few dozen authorised private flights (Wikipedia, 2020). Despite the short length of the closure, it took nearly until July 2004 - nearly 3 years - for the numbers of airline passengers to match and eventually surpass the numbers of passengers seen in the months before 9/11 (British Transport Statistics, 2017) due to the fear the event and its televised footage instilled in the general public, as well as the increased security measures at airports which made air travel more taxing for passengers (Ito and Lee, 2007). Travel demand dropped 31% in the five months following the attack, and revenues from domestic flights in the US fell by an estimated \$10 billion a year between 2001 and 2006 (Taylor, 2020). The overall revenue loss in North America due to COVID-19, however, had already reached \$64 billion by April this year (Statista

Research Department, 2020). The impact on the aviation industry of 9/11 was also seen in several, although not all, countries outside the US. Several airline services that were struggling financially before 9/11 outside the US went bankrupt after the event, including Ansett, Australian's second-largest air service, in 2001, and Air Canada in 2003 (Ito and Lee, 2007). European domestic demand showed a -17.4% ongoing decrease in demand for domestic flights, whilst Canada and Japan showed little change in demand after 9/11 (Ito and Lee, 2007). Contrastingly, the effect of COVID-19 has been severe all over the globe, and prolonged restrictions on all non-essential travel have led to a more significant drop in passenger air transport movements in the UK of up to 95% (CAA, 2020). However, some experts have commented on the similarities between 9/11 and the current pandemic - for example, Gary Kelly, CEO of SouthWest Airlines, said that the impact of COVID-19 "has a 9/11-like feel" in how the public's fear will decrease customer demand (cited by Taylor, 2020).

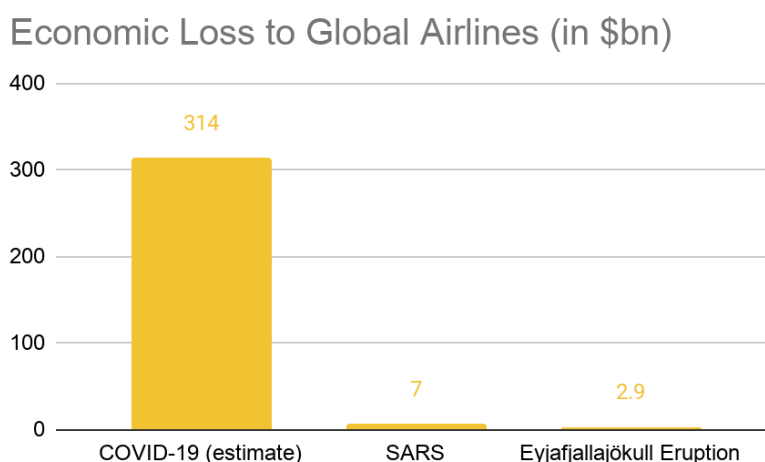
### **The 2008 Financial Crisis**

The global financial crisis that occurred in 2008-2009 was a period of rising unemployment and poor/negative economic growth for many industries, including the aviation sector. 87% of European airlines reported a reduction in traffic (CAPA - Centre for Aviation, 2009), and airline employees all over the globe were affected by redundancy, reduced working hours, pay freezes, and leave or working without pay - for example, British Airways employees were asked to work one month without pay (Harvey and Turnbull, n.d.). Similar effects were seen as a result of COVID-19 - for example, British Airways recently cut 10,000 jobs, with only 6,000 voluntarily accepting redundancy (Lea, 2020). However, the overall impact on air travel was actually fairly restrained compared to COVID-19's impact, with a 13% drop in passenger numbers, and a 15% and 8.7% drop in transatlantic and domestic travel respectively (Milmo, 2009).

### **The Eyjafjallajökull Eruption**

In April 2010, the Eyjafjallajökull volcano in the south of Iceland erupted, releasing a 9km plume of ash into the air. Large amounts of ash in the stratosphere makes flying extremely hazardous due to the risk of the ash affecting the air quality inside the cabin, damaging the plane's instrumentation, obscuring the windscreen, or causing the engine itself to stall. As a result of the ash produced by the Eyjafjallajökull eruption, Northern and Central Europe airspace was closed for six days, 108,000 or 75% of flights and 48% of European air traffic was cancelled, and more than 8.5 million passengers were stranded (Alexander, 2013). During the period from the 15th-21st of April, an estimated 1.7 billion USD in airline revenue for scheduled services was lost (Mazzocchi, Hansstein, and Ragona, 2010). Unlike the impact of COVID-19 and other pandemics, the eruption negatively affected both passenger and cargo flights, but the length of the aviation emergency was much shorter than the restrictions put in place as a result of COVID-19. Aerospace reopened in the UK just under a week after the eruption, with flight numbers returning to normal in Europe in just over a week. Although airline revenue was lost after the reopening when transporting the stranded passengers (Alexander, 2013), an economic drawback that COVID-19 will likely avoid, the eruption did not cause the same dramatic drop in demand leading to more long-term impacts, as seen with pandemics due to fear of

transmission, or with terrorist attacks like 9/11. Additionally, whilst the eruption's impact led to benefits for other alternate modes of transport, such as the Eurostar which showed 33% increase in passengers on 17th April (Mazzocchi, Hansstein, and Ragona, 2010), the same cannot be said for COVID-19. Public transport has shown decreases in passenger numbers due to the increased number of people working from home and lockdown measures. For example, according to the International Energy Agency (IEA, 2020), there has been a 95% decrease in underground journeys in London since the start of lockdown.



**Fig. 7 - Graph showing the approximate estimated economic loss in billions of US dollars to the global airlines for each event. COVID-19's value (\$314bn) is a prediction of the total economic loss after the pandemic has ended, made by the IATA (cited by The Guardian, 2020c). SARS' value (\$7bn) also comes from the IATA (cited by Pham, 2020), and the value for the Eyjafjallajökull Eruption comes from an estimated range in Euros predicted by Mazzocchi, Hansstein, and Ragona (2010), which I found the average of and converted into US dollars.**

The predictions for the aviation industry's recovery after COVID-19 compared to the recovery of these previous events

Many organisations have made predictions on the economic recovery of the aviation industry after the threat of COVID-19 passes. The travel restrictions issued for SARS had a devastating economic impact on Asia's tourism industry, but by August that year, arrivals had returned to their normal levels as seen at the beginning of March, before the WHO issued the travel advisory (Siu and Wong, 2004). The Eyjafjallajökull eruption caused a more extreme ban closer to that of Covid-19, but with a much shorter time frame. It also did not cause a significant drop in customer demand due to the public's fears, as seen with virus outbreaks like MERS and terrorist attacks like 9/11. As a vast, global pandemic, we may expect COVID-19 to cause a similar long-term drop in passenger demand. However, the situation for COVID-19 is uncertain and ever-changing. Many articles, including 'Economic Impacts of COVID-19 on Civil Aviation' by the International Civil Aviation Organization (ICAO, 2020), have evaluated the possibility of a

'V-shaped' recovery - the more optimistic prediction, with a quick recovery after a brief contraction period - or a 'U-shaped' recovery - the more pessimistic prediction, with a long contraction period and muted recovery. Several reports and articles such as 'A V or U-shaped recovery?' (Robinson, 2020) lean towards the likelihood of a 'tick-shaped' recovery, with a gradual climb back up to the contraction period. There is also speculation over whether the resumption of flights may initially require previously unseen precautions such as leaving the middle seat in each row empty, wearing various degrees of PPE, or even new, socially-distanced seat designs as proposed by Avio Interiors' (Robinson, 2020).

## **Results**

The following is a summary of the most important information gathered in this report. Data from the CAA shows that from April to June, the UK's ban on all non-essential travel has led to a drop in UK flights of up to 92.1%. This decrease in flights is mainly due to the up to 99% drop in passenger numbers and subsequent fall in UK passenger air transport movements of up to 95%, when compared to that of the same month in 2019 (CAA, 2020). Whilst UK cargo air transport movements have shown an overall increase during this period, peaking at a 73% overall rise in May 2020 compared to May 2019, the change from the same month the previous year in freight and mail transport varies from airport to airport drastically. The most recent data shows that July had an 87% decrease in air transport movements. The World Travel and Tourism Council predicts that the decrease in passenger flights will negatively impact international travel by up to 25%, and Maria-lacus et al. estimated that the aviation industry's losses could reduce global GDP by up to 1.67% by the end of 2020. According to IATA, the UK's aviation industry is predicted to lose \$26.1bn in revenue. However, Asia's aviation industry is predicted to be the worst affected, with a possible loss of 30 million jobs of the 50 million predicted to be lost worldwide (World Travel and Tourism Council, 2020).

The environmental impact of COVID-19's air travel restrictions can be estimated by looking at the changes in daily global carbon emissions, of which air travel is usually responsible for 2% (The Conversation, 2020). They were down by 17% in April 2020, but only by 5% in June 2020, according to National Geographic. Whilst Earth.org estimated a drop of 12 million tonnes in carbon emissions in Europe, readings from the Mauna Loa observatory show a peak in CO<sub>2</sub> 2.4 ppm higher than that of 2019 due to the continued build of CO<sub>2</sub> in the atmosphere (The Guardian, 2020d). In a survey conducted by Publicis Sapient, 58% of the respondents said that they were thinking more about the environment and sustainability now than before the pandemic began (Publicis Sapient and Skift, 2020).

COVID-19's impact is far greater in scale than any of the events discussed in this report, with a death toll already higher than any previous pandemic or outbreak of the 21st century, and a case number higher than that of all but Swine flu. The travel restrictions put in place to prevent its spread are greater in the long term than that of any previous event, and as a result, it is predicted to cause a \$314 billion loss to the airline industry, a sum far higher than even the estimated \$7bn loss to the airline industry caused by SARS, according to data from the IATA.

## Conclusions

COVID-19 has clearly had a severe and unprecedented impact on the aviation industry. The persistent drop in UK passenger numbers and the resulting estimated revenue losses, such as the global \$314 billion total loss to the aviation industry predicted by the IATA, far surpasses that of any caused by the other outbreaks and events discussed in this report. The vast number of current and predicted job losses in every sector of the aviation and aerospace industry is also a clear indicator of the social and economic damage of COVID-19. It seems unlikely that the aviation industry will have a swift recovery - even after the relaxation of the UK's restrictions on non-essential travel on the 4th July, passenger air transport movements were still down by 87% in July compared to the same period in 2019, only 8% less than the decrease seen in June 2020. This suggests that the fear of COVID-19 will have a long-term impact on customer demand, as did the discussed previous disease outbreaks of the 21st century, and the 9/11 terrorist attacks, where it took nearly 3 years for passenger numbers to return to normal (British Transport Statistics, 2017). Whilst it is hard to predict if passenger numbers will follow the same pattern for COVID-19, I agree with the many researchers such as Robinson, 2020 in predicting that the aviation industry may follow a 'tick-shaped' recovery, with a slow, gradual resumption of passenger demand. Like 9/11, COVID-19 has led airlines to input protective measures, such as Ryanair, who plans to make customers complete forms about their journey (Scotto di Santolo, 2020). As Ito and Lee (2007) suggested, new security measures after 9/11 caused a decrease in customer demand, so it is reasonable to assume that any new airport procedures due to COVID-19 would also reduce customer demand.

The information I collected suggest that the reduction in passenger flight numbers, whilst they contributed to short-term effects such as the drop in daily global carbon emissions of 17% in April (National Geographic), will not have a long-term or significant impact on climate change. CO<sub>2</sub> emissions in the atmosphere will continue to build up no matter how much flights are reduced, as shown by the Mauna Loa readings from this year (The Guardian, 2020). Also, the pandemic has led to several negative environmental side effects, such as the large increase in clinical trash produced daily (Saadata, Rawtani, and Hussain, 2020), and some airlines have increased their cargo flight numbers in the past few months, resulting in more carbon emissions. If no changes toward more eco-friendly transport are made by airline companies, once customer demand returns to normal, carbon emissions will also resume their normal levels, as Zambrano-Monserrate et al. (2020) discussed. After exploring this topic in my report, I believe that considerations towards climate change are particularly important in light of the pandemic and its impact on the aviation industry. As Mullaney and Baronett (2020) suggest, considerations toward the environment, particularly around reducing CO<sub>2</sub> emissions, are especially important in light of the current pandemic to climate change could affect customer demand in the long term, like COVID-19. Also, air pollutants including CO<sub>2</sub> often act as vectors for viruses, helping them spread (Paul Monks, cited by The Guardian, 2020), and an investigation is currently being undertaken into whether this could be true of COVID-19 (The Guardian, 2020). I believe that the relevance of greenhouse gases to the pandemic, as well as the positive short-term effects seen during lockdown, will aid the climate change movement after the threat of COVID-19 has passed. This idea is supported by the survey by Publicis Sapient, which suggests that people

are thinking about the environment more since lockdown. This links to the theory discussed by Trembath and Wang (2020) that lockdown and the travel restrictions may have gotten many people more accustomed to the concept of sacrificing activities now to prevent future dangers, a key concept of working against climate change, or may have changed individuals' opinions on the necessity of holidays, which would have a negative impact on the aviation industry, but a positive impact on the environment.

## **Evaluation**

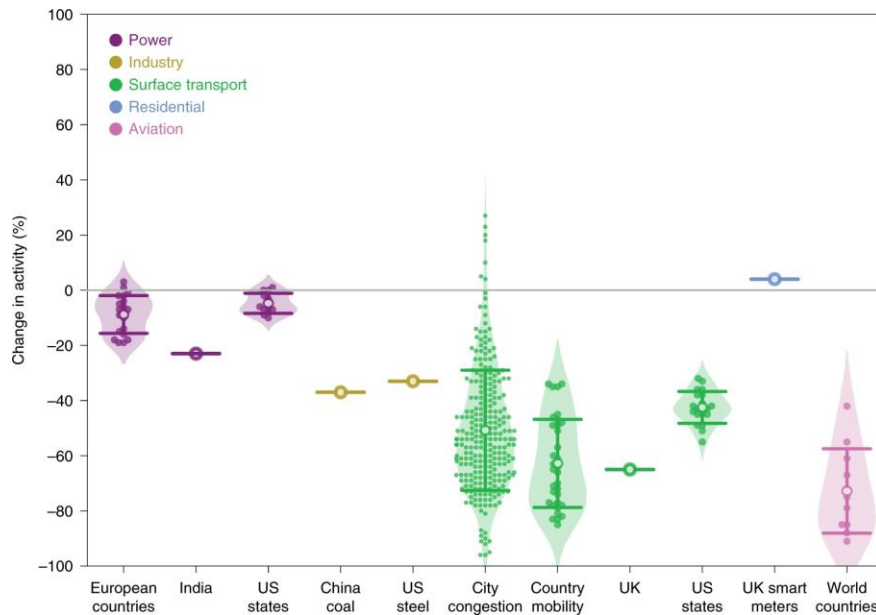
This project has allowed me to explore and educate myself on an area that I, before the project, had very little knowledge on. It has also allowed me to develop my research skills and experience writing a scientific report for the first time. Whilst I believe I have discussed a variety of points within the topic question, I realise that there are some areas that would ideally be covered or expanded upon. If I were to advance this report, I would research further into predicted recoveries for the aviation industry and find data on UK passenger flight numbers for the months following July to see how they change in light of the relaxation of UK travel restrictions. The impact of COVID-19 on non-commercial flights, business aviation companies, and the aerospace industry all could be analysed in more depth with further research.

I also would try to find a better way of comparing the impact of past events on the aviation industry to the current pandemic, as in this report I struggled to find the same statistics for each event to draw comparisons. This also meant that I couldn't include all the events in my graph, as I couldn't find the same information for each of them. In addition, many of the events I explored had a very severe impact in one area, but an insignificant impact in other areas, which was difficult to compare with the global impact of COVID-19. In my opinion, this area of the topic would be more easily explored in the years after the COVID-19 pandemic, as I had to rely on estimates and predictions to see what the impact may look like after the pandemic.

I would hope to expand my research into the impact of the travel ban on the environment by finding more specific statistics - I couldn't find any articles that focused on just the travel ban's impact on CO<sub>2</sub> emissions, rather than the overall change in CO<sub>2</sub> emissions caused by COVID-19, so I believe this area could be explored further if possible. I also would try to make my simple graphs more complex by looking into using different graph types to include more information. Finally, in doing my research, I noticed that there weren't many articles that compared COVID-19 impact on the aviation industry to other viral outbreaks, so I believe that this is an area that could be looked into more by researchers.

## **Appendix**

The following is a diagram that I was not able to use in my report, but is relevant to the research question and may be useful for those interested in the topics discussed.



**Fig. 8 - A diagram taken from ‘Temporary reduction in daily global CO2 emissions during the COVID-19 forced confinement’ (Le Quéré et al., 2020), this graph shows the change in activity seen in different sectors, including aviation, during lockdown.**

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