The Impact of the Covid-19 Pandemic on Air Traffic in the Asian Region: How the Aviation Industry Adapted Throughout the Pandemic

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Abstracts: The COVID-19 pandemic continues to pose a global threat, profoundly impacting various sectors, including the aviation industry. This research aims to uncover the impact of the pandemic on the aviation sector in the Asian region. Specifically, it explores the mandatory compliance of social measures and vaccination requirements imposed by governments, which have become crucial factors determining the feasibility of direct or international flights. The analysis focuses on several key aspects, including air traffic data, daily COVID-19 cases, vaccination rates, and implemented social measures within the Asian region. By examining the air traffic of each successful flight from departure to arrival, valuable insights into the aviation industry's perseverance throughout the pandemic are generated. Preliminary findings reveal a sharp decline in air traffic volume by -58.68% in 2020 compared to the previous year, attributed to the significant number of COVID-19 cases reported by December 31, 2020 (totaling 19,892,098 cases). However, the deployment of vaccination doses in 2021 has resulted in a modest recovery, with air traffic volume increasing by 12.64% compared to 2020. This recovery has prompted several countries to cautiously reopen borders and transition towards the recovery phases of the pandemic, despite the ongoing prevalence of COVID-19 cases. The research provides insights into the resilience and adaptability of the aviation industry, shedding light on the challenges faced and opportunities presented during the COVID-19 pandemic. By understanding the impact of social measures and vaccination requirements, stakeholders in the aviation sector can formulate strategies to navigate the current crisis and prepare for potential future disruptions. The findings contribute to the sustainable recovery of the aviation industry by informing policymakers, airlines, and other stakeholders about the factors influencing air travel in the Asian region. The analysis of air traffic, COVID-19 cases, vaccination rates, and social measures provides a comprehensive understanding of the aviation industry's response to the pandemic.

Keywords: COVID-19 Pandemic, Aviation Industry, Asian Region, Air Traffic, Social Measures, Vaccination, Resilience.

1. INTRODUCTION

The COVID-19 pandemic remains an important threat on an international level, with severe consequences for numerous industries, including the aviation industry. For the past two years, the industry has been impacted by major setbacks and obstacles where ensuring the safety of passengers became the crucial factor in preventing the transmission of the COVID-19 virus. This study intends to investigate the impact of the pandemic on the aviation industry, particularly in the Asian region. This study examines the mandatory compliance with social measures and vaccination requirements imposed by governments in various Asian nations as a crucial aspect. These measures are crucial determinants of whether direct or international flights are feasible. By analysing air traffic data, daily COVID-19 cases, vaccination rates, and implemented social measures, we hope to shed light on the pandemic resilience of the aviation industry. Notably, the research focuses on the air traffic of successful flights, considering both departure and arrival destinations within the Asian region. By examining the correlation between air traffic volume and COVID-19-related factors, we seek to shed light on the industry's ability to withstand the challenges posed by the pandemic. Preliminary findings indicate a significant decrease in air traffic volume, with a staggering -33.65% decline in 2020 compared to the previous year. This decline can be attributed to the reported 19,892,098 COVID-19 cases in the region by December 31, 2020. However, with the deployment of vaccination programs in 2021, the air traffic volume has shown a slight recovery, increasing by 2.23% compared to the previous year. This recovery has prompted several countries to gradually reopen their borders and transition towards the recovery phases of the pandemic, despite the ongoing prevalence of COVID-19 cases. By presenting comprehensive and tabulated results, this research seeks to provide valuable insights into the resilience and adaptability of the aviation industry in the face of the COVID-19 pandemic. Understanding the challenges and opportunities encountered by the industry

in the Asian region will contribute to the formulation of strategies for its sustainable recovery and future preparation.

1.1. Initial Phase of the COVID-19 Pandemic

In the province of Wuhan, approximately 59 suspected cases had been identified by early January 2020. The disease began as a local epidemic in Wuhan, China, but it swiftly spread throughout the world, being carried by foreign passengers. Due to the increased infectivity reported globally, various countries implemented planned or un-planned travel bans to limit the number of air travels throughout the year. Since then, a total of 9,236 new cases had been identified by 31st January 2020 in China. Thailand became the first country outside of China to confirm a case of the disease known as COVID-19 in January 2020. Per analysis, Thailand remained as the 2nd largest country where the COVID-19 outbreak was recorded with a total of 15 new cases by 31st January. Since then, various aviation industries have decided to halt flights entering and exiting from countries where new COVID-19 cases were detected. As of today, there is currently no scientific proof as to where it originated and as such this has been confirmed as a global pandemic, and dozens of western countries were concerned about the severity of the outbreak.

Table. 1: Total of 9,326 reported cases in Asian Region by 31st January 2020. Source by Ourworldindata

No.	Country	Total New Cases
1	China	9,236
2	Thailand	15
3	Japan	13
4	Singapore	13
5	Hong Kong	12
6	South Korea	10
7	Taiwan	9
8	Malaysia	8
9	Macao	6
10	United Arab Emirates	4
	Total	9,326

As of March 31, 2020, 854,307 confirmed COVID-19 cases, including 42,016 deaths, have been reported worldwide (World Health Organization (WHO), 2020). More than 190 nations were affected, with major epidemics in the United States (US), Italy, Spain, China, Iran, France, and other countries. The mortality rate from the Covid-19 in Italy has risen to over 15,000 since the end of February and is continuously rising, while the number of infected cases in the United States exceeds half a million people. Because to the rapid spread of COVID-19, most national governments, including Italy, have declared a state of emergency, and residents are not permitted to leave their homes. As a result, approximately 3.5 billion people worldwide have gone into self-isolation. The number of confirmed cases in the region continues to rise, but the rate of infectivity is declining. Nationwide lockdowns and enhanced community quarantine imposed in several nations, including Malaysia, Thailand, and Vietnam, are gradually being relaxed, and economic activity is beginning to recover up. Travel restrictions for international visitors, however, remain in effect. Singapore and Vietnam have established preventive and containment measures in response to the Covid-19 outbreak, comprising of test, track, and trace, which could serve as areference for other countries in the region and beyond (OECD, 2020).

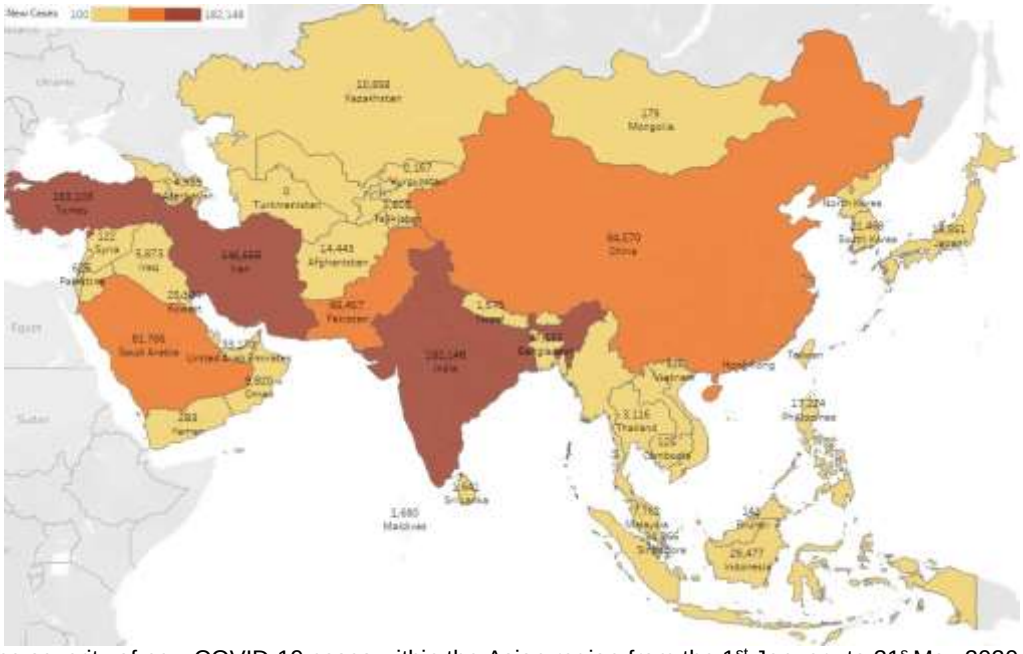

Figure. 1: The severity of new COVID-19 cases within the Asian region from the 1st January to 31s May 2020. Source by Ourworldindata.

Table. 2: Top 5 total Covid-19 cases in Asian Region by 31st May 2020. Source by Ourworldindata.

No.	Country	Total New Cases
1	India	181,827
2	Turkey	163,103
3	Iran	148,950
4	Saudi Arabia	83,384
5	China	82,454
	Total	659,718

By May 31, 2020, among the Asian region countries, India is now the country which is mostimpacted by COVID-19. Since May 31, 2020, India has surpassed Turkey after approximately 26,667 instances of Covid-19 were reported in the country. Turkey ranked second among Asian countries with 163,942 cases, followed by Iran with 151,466 cases, Saudi Arabia with 85,261 cases, and China with 82,470 cases. Despite China being the 1st country to be infected by the COVID-19, the strict social measures imposed by the Government proved to be effective where the rate of infectivity has sloweddown the infection.

2. LITERATURE REVIEW

2.1. The Global Impact of Previous Virus Outbreaks to the Airline Industry

The airline sector is characterised by poor profitability, regular new entrants, intense competition, heated fare conflicts, and stringent regulatory and safety standards. The implementation of big data technology has the potential to alter flights in a variety of ways (Odarchenko et al., 2019) such as detecting the flight patterns of Airlines within Asia during the pandemic and understanding the social measures for arriving and departing flights enforced in every Asian Countries. As such, the air traffic in 2019 is considered the pre-covid era when the airline industries within Asia were progressing as usual without the intervention ofany virus outbreaks since the MERS flu in 2015.

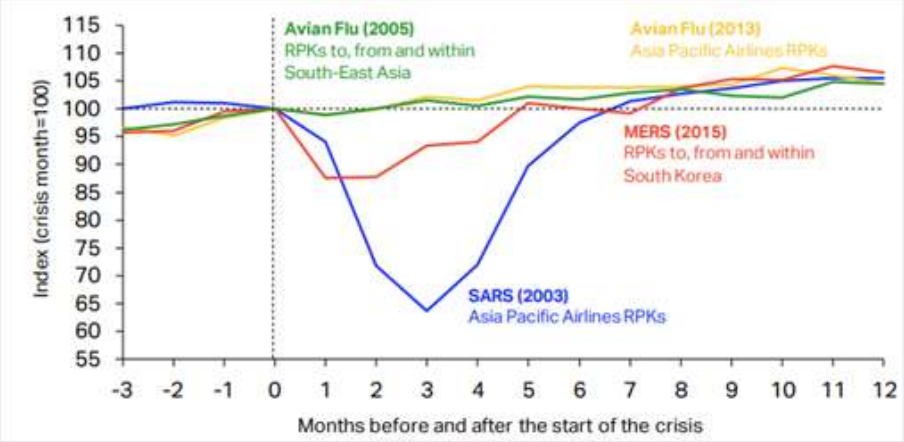

Figure. 2: The impact of previous outbreaks to global aviation industries. Reference from IATA Economics.

The previous bouts of disease outbreaks are depicted in figure (2) above to provide some insight into the potential implications of air travel. SARS has historically been the most catastrophic outbreak affecting transportation volumes in recent years. Monthly RPKs of Asia-Pacific airlines were approximately 35% lower than before crisis levels at the peak of the pandemic by May 2003. Overall, the lack of faith and concerns worldwide spread harmed both business and leisure travel to, from, and even within the area in 2003, causing Asia-Pacific aviation industries to lose 8% of yearly RPKs and $6 billion in revenue (IATA, 2020). On the other hand, the avian flu outbreaks in 2005 and 2013 were far weaker and shorter-lived, and air traffic swiftly recovered as fears of worldwide virus spread subsided. On the contrary, the two avian flu outbreaks in 2005 and 2013 had a lesser impact on the aviation industry due to several constraints placed by nations and airlines where the COVID-19 pandemic is widely known, highlyimpactful and has a widespread global impact compared to these diseases (I. Stefano, 2020). Despite the recent MERS Flu outbreak which was much more dependent on a specific country, the immediate impact was a severe deceleration, such as a 12% drop in monthly RPKs within South Korea throughout the first month of the unforeseen outbreak (I. Stefano, 2020). Consequently, the air travel volumes began to recover after 2 months and recovered to pre-outbreak rates within 6 months. As today's figure indicates, the aviation industry has historically been resilient to shocks, including pandemics. Even during the SARS pandemic, monthly international passenger volume rebounded to pre-crisis levels in 9 months. Nonetheless, the Chinese air transport business has grown rapidly in recent years, with an additional 450 million people flying to and from China each year compared to a decade earlier. This epidemic has also coincided with New Year's celebrations and China's peak travel periods. Although there is a chance that this pandemic may create substantial change, history suggests that any impact on airtravel would be brief (IATA, 2020).

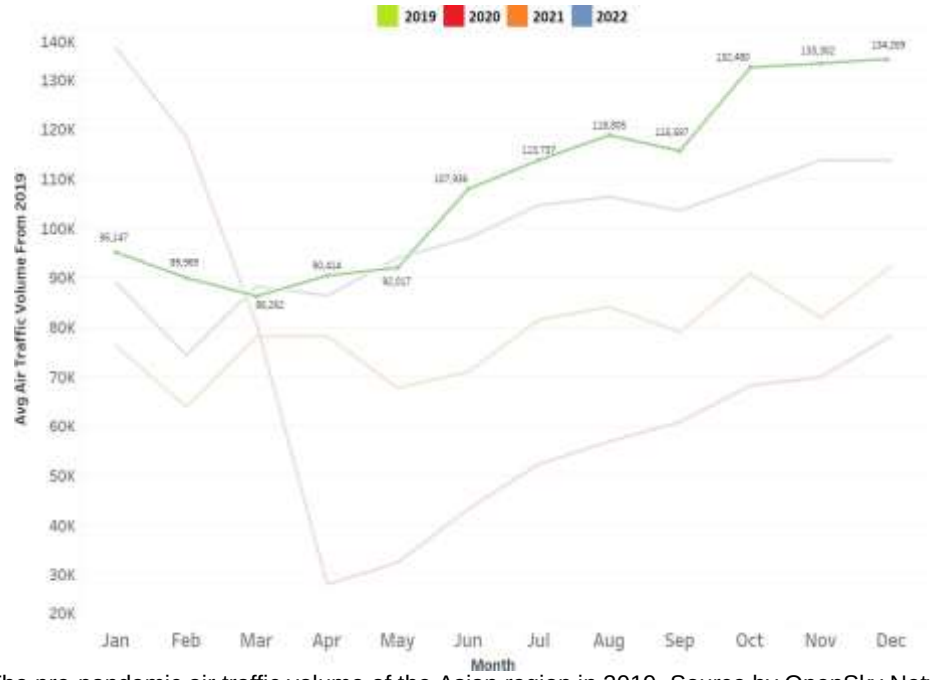

Figure. 3: The pre-pandemic air traffic volume of the Asian region in 2019, Source by OpenSky Network. The Y-axis represents the Average Air Traffic Volume from the pre-pandemic year of 2019. The X-axis represents the Months in contrast to the associated Years (colour boxes).

The use-case to include the 2019 air traffic serves as the benchmark where the continuous air traffic is the indicator to ensure the endemic air traffic chart in 2020 and 2021 are transitioning back to normality. Hence, these charts will be drilled down to further analyse the crucial events that occurred within the pandemic era where there were several countries within Asia are facing a huge surge in the number of Covid positive cases. Many local hospitals in Wuhan, China, reported an extraordinary number of patients with severe pneumonia with no known cause who did not respond to any type of vaccine or prescription in the last weeks of 2019. (Chen et al, 2020) Furthermore, due of human-to-human transmission, doctors discovered that this unknown disease had a comparable pandemic of severe acute respiratory syndrome (SARS) in 2002 (Peiris & Poon, 2008), and the nature of the pandemic which is like SARS was identified as the corona virus. The World Health Organization (WHO) eventually designated this virus as novel corona virus (nCOV-19) or COVID-19.

3. Datasets Usage and Resources

3.1. Research Objective and Methodology of Big Data for Aviation Industry

To clearly understand the effects of the global pandemic, data sources from specified publishers were made to combine into 1 central dashboard. Furthermore, this section will describe the sources of data which were selected to provide the overall insights of COVID-19 and the effects on the aviation industries. The key methodology of this research is mentioned below:

- To combine datasets of air traffic, Covid-19 cases, government social measures and vaccination rates to reveal the insights of how the airline industries cope within the COVID-19 pandemic.

- The implementation of big data technology has the potential to alter flights in a variety of ways (Odarchenko et al., 2019) such as detecting the flight patterns of Airlines within Asia during the pandemic. Also, understanding the social measures for arriving and departing flights enforced in all Asian region countries are crucial in determining the severity of the COVID-19 pandemic.

Airlines referred to big data as the "third wave" following traditional databases and online content (Hausladen and Schosser, 2020). The airline industry is characterized by poor profitability, regular new entrants, intense competition, heated fare conflicts, and stringent regulatory and safety standards (Chen et al., 2020). Since Big Data can provide adequate, real-time, and enhance (Lee, 2017) the preventive measures of aviation flight's potential dangers, the introduction of the Big Data era enables the modern aviation industry to develop solutions for its greatest obstacles of safety and performance improvement (Dou, 2020). As such, Big Data will efficiently boost the performance capability and operative circumstances of aircraft, prevent a variety of unfavorable external factors, and decrease manual mistakes to improve flight safety (Dou, 2020). Furthermore, short-term projection and managing of unpredictable events might be also the primary purpose for airlines to be prepared for the ever-changing flight trends and restrictions that is imposed through Asian countries during the pandemic.

3.2. Global Air Traffic Data – OpenSky Network

The air traffic date is utilized by aviation industries to plan and anticipate their business. Also, air traffic data is used to adapt to the airlines respective flight plans and itineraries considering the changing of travel restrictions, passenger demand, and other variables during the COVID-19 pandemic. Based on the consequences and uncertainties, airline companies must modify their scheduled flights and destinations due to shifting travel bans and passengers' safety requirements. As such, they were able to determine the safest routes in compliance to the country's social measures and organise their own resources assigned to their respective flights. With the utilization of air traffic data, various insights can be derived to identify the Asian countries which are considered as “hot zones”. These countries will be the key identifier for flight planners to understand what are the social measures and restrictions that are enforced by their government.

The data below shows the raw dataset of OpenSky Network where the origin and destination of an aircraft are based on airport codes that are known as the International Air Transport Association (IATA) location identifier. In addition, the general airport code can be difficult to distinguish as the code does not resemble the country or airport abbreviations which makes it difficult for analysts to locate the original location of the airports. To ensure that the air traffic data can be identified based on its IATA code, the merging of another dataset is used to provide the exact airport naming, country, and region below:

Table. 3: The sample of air traffic volume datasets by OpenSky Network.

Callsign	Origin	Origin_Airport	Origin_Country	Destination	Destination_Airport	Destination_Country	Firstseen	Lastseen
MAS1152	WMKK	Kuala Lumpur International Airport	Malaysia	WMKP	Penang International Airport	Malaysia	2021-12-01 08:34:16	2021-12-01 09:03:23
CSS7229	WMKK	Kuala Lumpur International Airport	Malaysia	ZGSZ	Shenzhen Bao'an International Airport	China	2021-12-01 08:40:37	2021-12-01 12:30:07

With the elaboration of the air traffic dataset, the flight patterns can be derived to further understand the number of flights from the departing and arriving countries. This will produce an in-depth analysis of where the flight was made possible during the Covid-19 pandemic where various countries have imposed their own social measures to restrict passengers from entering or departing the countries.

4. RESULTS AND ANALYSIS

4.1. The Impact of the COVID-19 Pandemic towards Aviation Industry

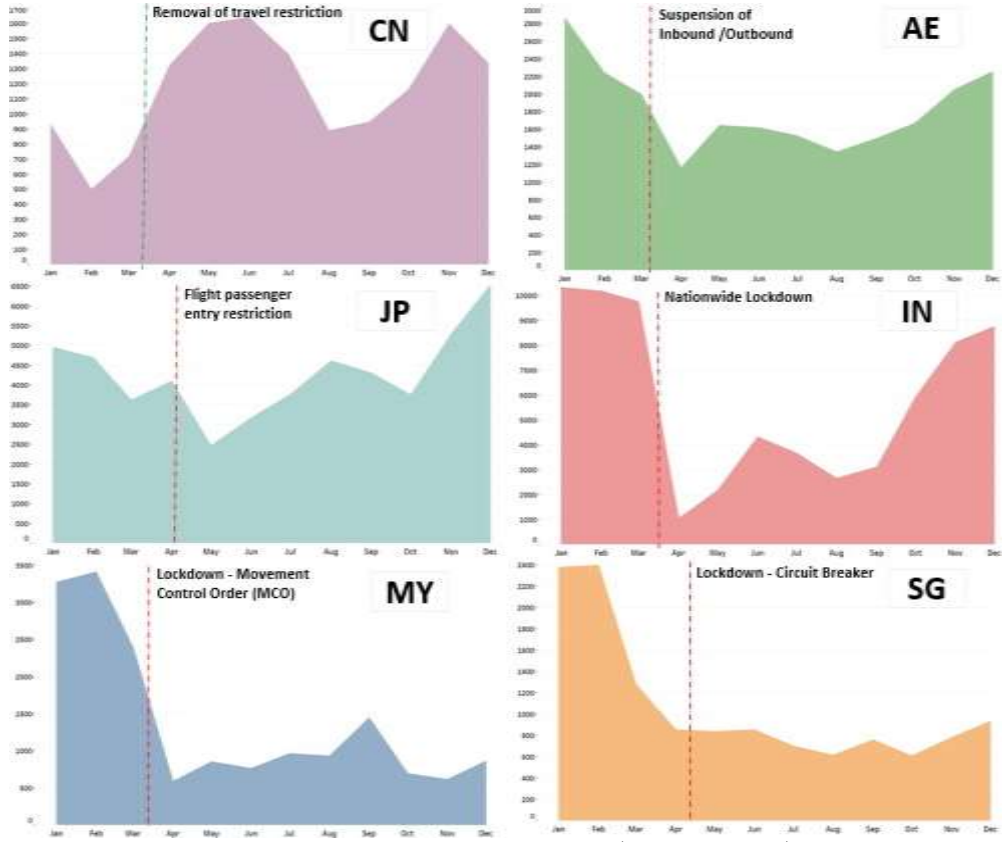

Figure. 5: The air traffic volume of 6 Asian region countries from the 1st January to 31st December 2020. The enforcements of travel restriction and lockdown were implemented globally within March – April 2020. Source by OpenSky Network.

Table. 4: The enforcement of flight containment measures in several Asian region countries from the 13th March – 7th April 2020.

Date	Country Code	Country	Containment Measures	Description	Source
13-Mar-20	CN	China	Removal of travelrestriction	The states of Qianjiang and Huangshi became the first Hubei cities to have their travel restrictions removed. By 8th April 2020, most cities in China had begun to removethe travel restrictions, and local flights had been resumed. Also, flights to the EU resumed at the beginning of June.	(Zhong & Wang, 2020)
8-Mar-20	MY	Malaysia	Lockdown - Movement Control Order (MCO)	The Malaysian government implemented the country's first phase of the Movement Control Order (MCO). Air travel has been severely restricted throughout the lockdown timeframe, and movements have been limitedwithin the country. Also, international, and local flights were heavily reduced to prevent the transmission of COVID-19 in the country. Besides, the government suspended foreign visitors from all countries entering Malaysia; however, some exceptions were allowed for permanent residents, locals, diplomats, and foreign workers to enter the country.	(Shah, Ain Umaira Md et al, 2020)
19-Mar-20	AE	United Arab Emirates	Suspension of inbound/outbound flights	The UAE had implemented various measures to restrict inbound and outbound flights within the country. However, cargo and evacuation-based flights were permissible by adapting to the latest social measures	(N. Turak, 2020)

25-Mar-20	IN	India	Nationwide Lockdown	On the 25th March 2020, the Indian government announced the nationwide lockdown known as the (Lockdown 1.0). Throughout the lockdown timeframe, all international and local commercial flights were suspendedtill 14th April 2020. By 25th May 2020, domestic flights were resumed in phases, and strict protocols were applied. However, international flights were still suspended.	(D. Arora et al, 2020), (A. De, 2020)
03-Apr-20	JP	Japan	Flight passengers' entry restriction	The Japanese government had enforced entry restrictionson foreign passengers from Asia, the EU, and the NA to prevent the spread of COVID-19. Also, The governmentdeclared a nationwide emergency on the 7th April 2020 by forcing local businesses to halt their operations temporarily and initiating voluntary measures for their citizens to stay home.	(J. Stacey,2020)
07-Apr-20	SG	Singapore	Lockdown - Circuit Breaker	The government of Singapore declared that all returning residents and long-term residents with permits entering the country would be required to serve a 14-day Stay- Home Notice (SHN) at designated centres. In addition, all non-essential services were suspended, and a temporary lockdown known as "Circuit Breaker" measure was implemented, including the closure of most companies, organisations, and retailers. Singapore initiated a phased approach to reopen its borders at the beginning of June. However, entry was permitted for essential travel, and specific groups of flight passengers were subjected to mandatory testing and quarantine requirements.	(Toh, 2020), (J.Geddie & A.Aravindan, 2020)

Throughout the lockdown, commercial flights were experiencing restriction to depart and arrive within Asia countries where many borders were not willing to take the risk of accepting travellers despitebeing them tested negative before boarding their respective flights. With the strict social measures in placed in every Asian country, this had an immediate and severe influence on airport traffic and income. In the early aftermath of the pandemic, the economic crisis will continue to drive lower demand for air travel. Consequently, the pandemic has impacted global passenger travel. The disruption originated in Asia-Pacific, but the sudden spread of the virus and the containment measures were implemented in response, such as government advisories to avoid travel and airport closures, caused widespread damage.

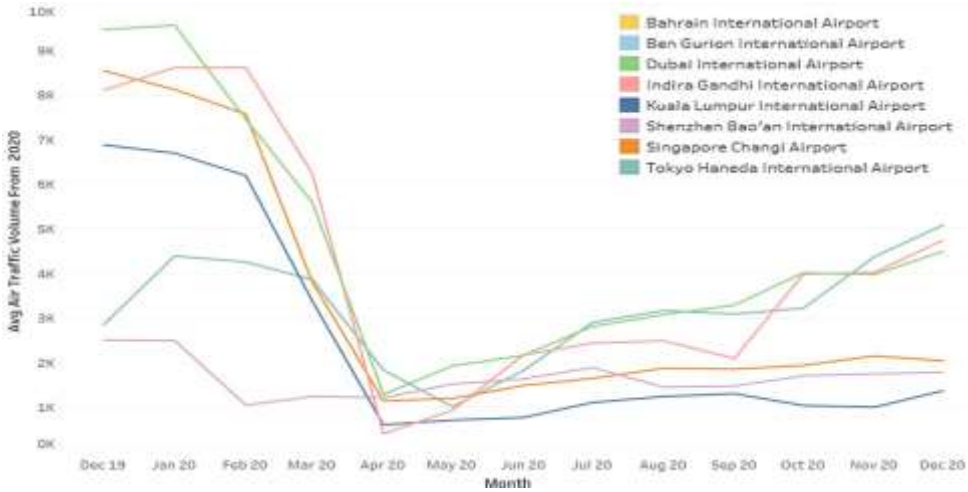

Figure. 6: The trend lines of several Asian international airports that were impacted by the COVID-19 pandemicfrom December 2019 to December 2020. Source by OpenSky Network.

By referencing to figure (6) above, the nationwide lockdown and air traffic preventive measures have been enforced within specific countries. As the enforcement began, the drop of air traffic volume by arrival and departure of international airports within the Asian region have been restricted to comply with the strict COVID-19 protocols set by WHO. Different authorities determined how in-flight procedures adjust during quarantine, resulting in diverse protocols (Bielecki et al., 2021). Passengers ought to, for example, conform to procedures deemed essential by the country of departure, the country of arrival, the airline, and other organisations such as IATA. Particularly, airlines find it difficult to comply with COVID-19 prevention guidelines, as they are profit-driven and are compelled to maintain flight services by maintaining passenger demand high, regardless of the potential negative effects on the health and safety of passengers (Bielecki et al., 2021). As airlines reduce capacity, the aeronautical income airports receive from airlines, such as landing fees and security fees, decreases. As people stop flying, non- aeronautical revenue from airport parking lots, eateries and duty-free shops falls. Many airports are still accessible for cargo operations, which should help airports. Cargo operations, on the other hand, were impacted by airline capacity reductions because cargo frequently travels in the belly of passenger planes (I. Twinn et al, 2020). As a result of the pandemic, both demand and capacity for air cargo declined in February 2020, even though airline rates were substantially higher. In any event, cargo revenues account for only a minor portion of total airport revenue which is less than 10 per cent. Both projected airline possibilities and a structural shift in demand may intensify the present situation:

- Airline financial health - Possible airline bankruptcies pose a significant risk to airports, particularly airports that serve as hubs for struggling carriers.

- Changes in structural demand - Airports are anticipated to see structural changes in demand because of the economic crisis that will follow the COVID-19 outbreak. Airport efficiency will be hampered by lower-than-expected global GDP growth following COVID-19. As a result, industry analysts predict that the recovery would be much slower compared to prior worldwide tragedy such as the 9/11 or SARS.

- Earnings evaluation and credit losses – As a result of dramatically lost revenue and ongoing uncertainty surrounding COVID-19, major airport operators are revising their earnings expectations, and credit reporting agencies have downgraded numerous airport operators' lengthy debt ratings and/or amended their perspectives to negative.

4.2 Mandatory Enforcement of Social Measures to the Public

During the early phases of the outbreak, national regulatory agencies issued operational guidelines to airlines and airports on how to protect against the virus and deal with cases when they surfaced. These directives included isolating suspected cases, thorough cleaning sanitising of the aircraft, and quarantining crews suspected of being infected with the virus. Airports were instructed to employ non-contact temperature monitoring to identify and isolate suspected cases as quickly as possible. However, all of this was done on the assumption that thorough tracing of suspected cases' contacts was achievable. The difficulties for such strategy spanning from many governments' inability to ramp up to high levels of testing to flaws in the tests themselves (with several giving false negatives of up to 30%), and the time required to develop a vaccine or reliable indicators of immunity, have caused the industry to desperately find for operating practices that will make aviation safe enough to recommence (D. Elliot, 2020). Such policies due to the fact they must be on social distancing would put airline and airport economies under great strain as all Asian region countries have taken steps to contain or mitigate COVID-19 spread and among these preventive measures are:

- Declaring a state of emergency, imposing lockdowns across countries or large cities, or imposing curfews.

- Reducing the likelihood of virus importation by restricting borders partially or completely. As a containment measure, the measures were implemented by instituting screening at a country's authorized entrance point and imposing travel limits or restrictions.

• Limiting community transmission through social separation, such as school and public-sector closures. This eliminates the possibility of individuals meeting one another.

• Imposing fine on individuals violating the law. Given the possibilities of spreading the virus, several individuals were caught putting another individual at risk of getting exposed to the virus.

Due to these unforeseen circumstances, the government had no choice but to impose this strict law of social distancing.

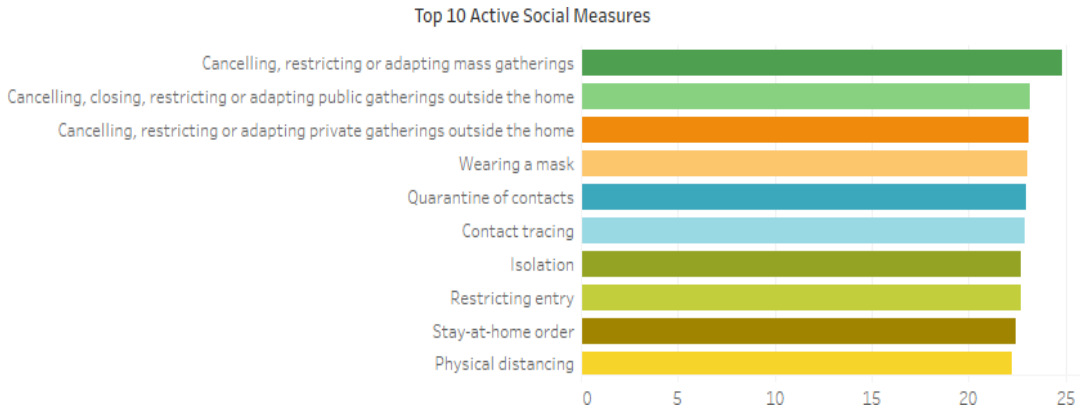

Figure. 7: The Top 10 enforced social measures within Asian region from 1st January 2020 to 1st January 2021. Source by WHO - Public Health and Social Measures (PHSM).

The figure (6) above represents the social measures that were imposed throughout the duration of the lockdown in most Asian countries from January 1st 2020 to 1st January 2021. As most of the social measures were imposed on the aviation industry, the restrictions above show that on any occasion whether it is in an enclosed or public area, the number of human interactions among one another must be either greatly minimized or cancelled. The severity of permitting such interaction to occur will tend to further spread the virus based on surface contacts. As a workaround to prevent the widespread of the virus, further preventive measures have been imposed to ensure the public are enforced to always wear their mask. Below is the full explanation of the type of social measures commonly enforced to airline passengers from entering/exiting the country that is recognizable by WHO:

Table. 5: To ensure the resumption of international and domestic flights, the table above specifies the type of social measures enforced to airline passengers in the Asian Region countries. Source by Assessment Capacities Project (ACAPS).

Category	Measures	Description
Movement Restrictions	Additional health/document requirements upon arrival	The need of health declaration or doctor's certificationsto allow entry.
	Border checks	Identification document checks in land and sea entrypoints of a country.
	Border closure	A country restricts the land and sea border with the neighbouring countries.
	Complete border closure	A country has completely restricted the borders for all - including nationals.
	Checkpoints within the country	Installed check points within the country on district borders or main road to conduct health verification andhalt the internal movement of people.
	International Flights suspension	International and/or internal flights are suspended by government.

	Domestic travel restrictions	Authorities are controlling and limiting the movement ofpeople within a country/district.
Public Health Measures	Introduction of isolation and quarantine policies	Undergo self-quarantine or put in isolation units uponarrival to a country.
Health screenings in airports andborder crossings		Health screening and body temperature checks are conducted in airports and border crossings.
	Psychological assistance andmedical social work	Implemented measures for the phycological assistanceof all people in quarantine or lockdown.
Requirement to wear protectivegear in public		Mandatory of Masks/ gloves usage.
	Others public health measures enforced	Example, sanitation of transports and additional health regulations.
Lockdown	Partial Lockdown	Essential-based stores are allowed to operate.
	Full lockdown	The population not allowed to leave their housesunless if there's a valid reason approved by law enforcements.

Most Asian region countries involved in the global pandemic apply these following rules to prevent the widespread of disease. With that, these practices have managed to flatten the infection curve but with the consequence of economic decline. These social measures are used to track the measure taken based on the number of times government had extended or excluded measures in a different manner. Besides, should there be any positive cases among the public, the authorities are deployed to conduct contact tracing to ensure the infected are segregated from the public by undergoing mandatory quarantine. Furthermore, should there be any close contact with the infected cases, the individual will be traced to ensure they are not infected by the virus and are encouraged to undergo home quarantine. Throughout the widespread of the virus, the public is forced to adopt the 1-meter ruling of physical social distancing to ensure they are separated from other individuals who could have been infected by the virus. As such,most of these social measures above lasted for more than 20 days depending on each of the countries' restrictions imposed on the public. Due to these social measures, various industries were forced to halt their operations and the aviation industry was greatly impacted by these rules as physical distancing was challenging to be imposed.

4.3. Adaptation of Aviation Social Measures During Pandemic

The number of air travels within Asia were at the highest of average 136,474 flights in January where many travellers were in fear of the potential pandemic where many are speculating if they can enter their home country should the borders be closed to prevent the spread of Covid-19. As such, the growing concerns of the pandemic has prompted many travellers to enter or exit a certain country despite several countries have imposed the traveling ban by February to March. Before the lockdown, the average number of travellers by March were reduced to 80,441 which shows the decrease of -69.66% hence followed by the imposed lockdown by April where the average number sharply declined to an astounding 27,997 flights. Throughout the most severe stage of the pandemic, a vast majority of nations closed their borders for both arrival and departure travel, limiting traffic to the repatriation of passengers and essential commutes and occasionally to every kind of travel. In some instances, obligatory quarantine was mandated, except for domestic travel, which has generally been less restricted and subject to less stringentsafety measures. Despite the increasing number of COVID-19 cases from the end of August, September and throughout October, the Asian countries have acclimated to the "new norm" recommendations and restrictions despite the rapid implementation of changes. Within the timeframefrom June 2020 – September 2020, the trend shows a gradual transition to the safe recovery of air traffic despite the increasing cases of COVID-19 reported in Asia. The June data show only a slower rebound in domestic markets in China and the United States, while the international passenger segment remained practically non-existent, negatively impacting airport financial results and stalling recovery (de Oliveira, 2020).

In contrast to the analysis, the flight trend in Asia has seen an increase of 5.6% from an average of 43,237 flights in June 2020 to 60,857 flights in September 2022.

Figure. 8: The air traffic volume in the Asian region from 2019 to 2020, source by OpenSky Network. The number of international & domestic travels beginning of March 2020 were severely limited due to various countries' restriction or lockdown based on figure (5).

Three major criteria may influence the decision to resume an international flight. First, it should include nations who are exploring mutually lowering mobility restrictions, since it makes little sense to establish a flight with a country that is currently under stringent lockdown. Second, increased emphasis should be placed on safe regions or locales to reduce the risk of coronavirus transmission. Third, greater incentives should be provided to open routes that will bring more visitors and economic benefits. Governments must not only consider these three aspects while making decisions, but also assessing them throughout time. Despite the ambiguity surrounding the pandemic, a move may look acceptable at one point in time but maybe incorrect or harmful after some time due to ongoing cases reported around Asia (Kai Kaiser et al, 2020). Despite the consistency in June and July 2020, the recovery within the aviation industry remains uncertain. Forcible national measures such as quarantine prerequisites are harmful to both the industry and passenger confidence, and Airports Council International (ACI) had advised governments to abide a reliable and comprehensive testing protocol that should be implemented only when necessary and as an alternative to wider quarantine requirements. Gradually, from October 2020 – December 2020, the air traffic volume has seen an increase of 14.68% despite the COVID-19 pandemic still had a significant effect on air travel in the Asian region. Even though some travel within countries had resumed, foreign travel was still minimal because many countries had put in place travel bans and quarantine measures. Consequently, there was still considerably less air movement within the region than before the pandemic. Different passengers in the area dealt with the rising number of COVID-19 cases and social distance measures differently due to various countries and planes had different rules and policies in place. Most of the time, people had to wear masks on flights and in airport terminals, and some companies made them take COVID-19 tests before boarding.

5. DISCUSSION

5.1. Vaccination Rate in the Asian Region

Singapore was the first country in Southeast Asia to provide Covid-19 vaccines to its citizens and residents. The first phase of the island nation's vaccination program occurred on 30 December 2020, a few days after the country received an unspecified number of dosages from Pfizer. Indonesia succeeded on January 13, 2021 (E.Tarigan & V. Milko, 2021), initially using a Chinese vaccine produced by Beijing-based Sinovac Life Sciences. Subsequently, Southeast Asian nations, including Malaysia, Thailand, Laos, Myanmar, Cambodia,

and Vietnam, have received vaccines from various sources in stages. By April 2021, all Southeast Asian nations will have initiated nationwide vaccination initiatives; this indicates effectively for the region's recovery effort if the momentum is maintained. The varying levels of vaccine access among countries have been an important issue, as this reflects earlier findings from the beginning of the year when only 16% of the world's population resided in wealthy nations, which had access to 60% of the vaccine doses (A.C Wong, 2021).

5.2. Vaccination Passport for International Travel

The rate at which a population can be vaccinated is also strongly correlated with the likelihood of reinstating substantial population migrations across nations. Consequently, the idea of 'vaccine passports' has piqued the curiosity of authorities.

The re-establishment of international travel through establishing procedures for vaccine certificates was crucial to guaranteeing that passengers were allowed to board the flight to their intended destination. As such, this initiative of vaccine certificates could be followed by developing a unified vaccine passport recognition database in Southeast Asia, allowing for the progressive resumption of regional travel as safely and effectively as possible. The final phase is to institute phased quarantine measures over time where passengers will be required to fill up their respective information based on the type of vaccine they have taken, such as Sinovac, Pfizer, AstraZeneca, Moderna, and others.

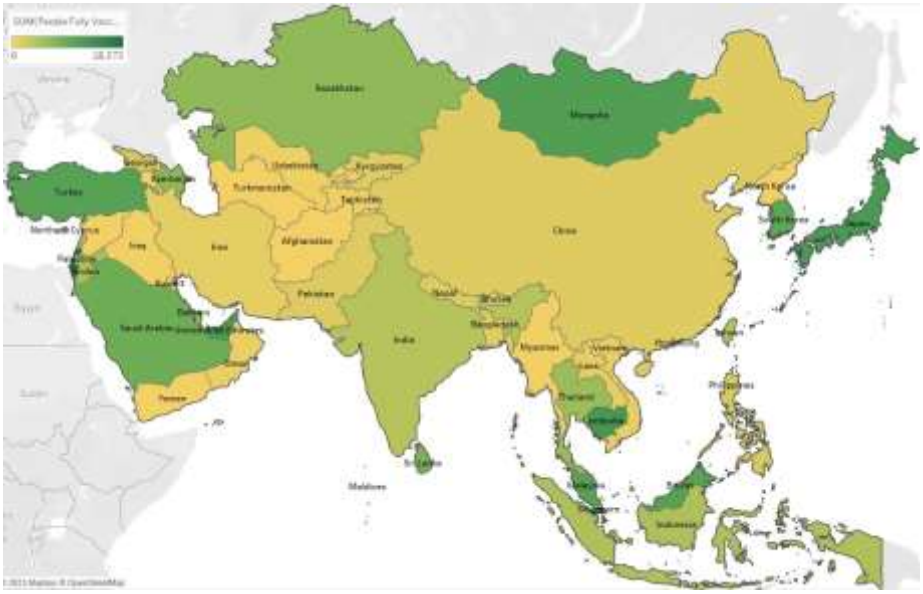

Figure. 9: The countries approaching herd immunity based on the vaccination rate per hundred from 1st Januaryto 31st December 2021. Source by Ourworldindata.

Table. 6: The top 10 Asian region countries with the highest rate of people fully vaccinated per hundred. Source by Ourworldindata.

No.	Country	People Vaccinated Hundred	Fully Per	People Vaccinated Per Hundred	Total New Vaccination	Population
1	Bahrain	18,373		21,028	2,762,551	1,472,237
2	Israel	18,286		20,818	15,800,525	9,449,000

3	Singapore	15,892	18,765	11,795,465	5,637,022
4	Cambodia	11,660	13,619	30,116,828	16,767,851
5	Japan	11,135	13,159	201,528,029	123,951,696
6	United Arab Emirates	11,068	10,877	18,981,681	9,441,138
7	Maldives	10,661	16,377	702,479	523,798
8	Mongolia	10,498	12,610	4,314,289	3,398,373
9	Malaysia	10,060	12,056	57,895,737	33,938,216
10	Turkey	10,007	13,042	130,872,372	85,341,248

Israel became one of the best countries in administrating 15 million COVID-19 vaccine by December 2020 and has achieved the milestone of having two thirds of their population fully vaccinated. The exceptionally high vaccination rate led to a considerable decrease in COVID-19 cases and hospitalisations in the country, which has documented the lowest-ever weekly ICU admissions of 5 individuals per day by 31st December 2021. The herd immunity milestone of Israel has been the key success of ensuring the safety path to re-opening the country's borders throughout 2021. Several other countries for instance Singapore and Bahrain have taken measures to loosen the restriction of entering the country by applying preventive measures to prevent the spread of COVID-19 to its local citizen. The reopening of Singapore's borders was accomplished in stages. As of October 2021, Singapore had set up several travel lanes, such as the Vaccinated Travel Lane (VTL), which authorized vaccinated passengers from certain countries or regions to enter the country without quarantine or with reduced quarantine requirements (A.C Wong, 2021). To ensure a low risk of COVID-19 transmission, various countries in the Asian region must ensure that most citizens have been fully vaccinated and even produced negative test results to authorize their departure from the originated country. In conjunction with specific health and testing protocols, these precautions were taken to guarantee the well-being of both residents and passengers (A.C Wong, 2021).

5.3. Average Air Traffic Volume Before and During the COVID-19 Pandemic

In the early phases of reopening their borders by mid-2021, the gradual increase of every country's vaccination rate enables the Asian region countries to prioritize the specific categories of passengers or essential workforce members. As the COVID-19 situation stabilized, fully vaccinated people were the first to be authorized to travel, while other varieties of passengers were progressively added. To fulfil the travel prerequisite, the country's population must be fully vaccinated by more than 50%. This systematic approach ensured a careful balance between public health concerns and the reinstatement of international travel. Most countries implemented vaccination certificate systems or health passes to verify the vaccination status of passengers, as these credentials served as a crucial indicator for vaccinated passengers that they have received at least two doses of the vaccine to facilitate streamlined admission procedures. In addition, stringent testing protocols, including pre-departure and arrival testing, were implemented to guarantee passengers' safety and reduce the risk of Covid-19 transmission. Despite the ineffectiveness of temperature screening, airports must conduct mandatory rapid assessments, potentially a combination of spit and antigen, at all arrival locations (Bielecki et al., 2021). In the event of an outbreak, these preventive measures are the best way to limit the number of passengers who must be placed in quarantine upon arrival. Additionally, cleanliness of the hands, physical separation from entering an airport until the point of exiting an airport, and continuous facial coverings are essential components for preventing Covid-19 transmission.

Figure. 10: The overall air traffic volume in the Asian region from the year 2019 to 2022, source by OpenSky Network. The Y-axis represents the Average Air Traffic Volume from the pre-pandemic year of 2019 till the endemic phase of 2022 white the X-axis represents the Months in contrast to the associated Years (colourboxes).

Table 7: Total average flights and changes (%) of air traffic volume within the Asian region from 2019 to 2022. The total average air traffic volume in 2020 were decreased by -58.68% compared to 2019. By 2021 onwards, various Asian region countries had re-opened their borders for international travels as they began transitioning to the endemic phase.

Month	Avg Flights 2019	Avg Flights 2020	Avg Flights 2021	Avg Flights 2022
January	95,147	136,474	76,321	89,006
February	89,969	118,474	63,850	74,331
March	86,262	80,441	78,154	88,302
April	90,414	27,997	78,203	86,370
May	92,017	32,464	67,739	93,981
June	107,936	43,237	70,957	98,058
July	113,737	52,300	81,511	104,616
August	118,805	56,898	84,122	106,358
September	115,597	60,857	79,032	103,603
October	132,480	68,211	90,858	108,648
November	133,302	69,931	81,812	113,738
December	134,269	78,222	92,385	113,721
Total Avg Flights	**109,161**	**68,792**	**78,745**	**98,394**
Change (%)	N/A	**-58.68**	**12.64**	**19.97**

The effectiveness of travel restrictions in controlling infection depends upon several variables, including the length and duration of the restrictions, the magnitude of the epidemic, the transmissibility of the virus, and travel patterns (Bielecki et al., 2021). Quarantining passengers from a country with a declared outbreak may delay the spread or reinfection of the virus, as the passengers' symptoms may manifest between 5 and 14 days after their departure. To limit the likelihood of reinfections, governments implemented robust monitoring systems to assess

the evolving domestic and global COVID-19 situation. Risk assessments of the epidemiological landscape in various nations and regions played a crucial role in determining the level of travel restriction relaxation, thereby protecting public health interests (K. Omar et al., 2022). Consequently, amid the loosening of travel restrictions, countries remained committed to maintaining public health by adopting the most recent social measures. To mitigate the risk of COVID-19 transmission, thus guaranteeing the safety of passengers and reducing the potential of outbreaks, mask use,social distancing, and improved hygiene practices were mandated and strictly enforced.

CONCLUSION

The COVID-19 pandemic has significantly impacted the Asian aviation industry, prompting this research study to investigate its effects and assess industry resilience. Factors such as vaccination rates, social measures, and air traffic volume were analysed. Varying vaccination rates across Asian countries have influenced recovery efforts, with Singapore and Indonesia leading vaccination programs. Vaccine availability and speed of vaccination have determined the feasibility of international travel, prompting the emergence of vaccine passports. Israel's successful vaccination efforts resulted in reduced COVID-19 cases, while Singapore and Bahrain gradually reopened their borders with preventive measures. Air traffic volume declined by -58.68% in 2020 but showed a 12.64% increase in 2021 due to vaccination deployment. As the vaccination rate gradually increases globally, various airline industries have resumed their international and domestic flights in 2022. Based on the transition to the endemic phase, the Asian

region's air traffic volume increased by 19.97% compared to 2021. Hence, the study's insights highlight the industry's adaptability and resilience, guiding policymakers and stakeholders in formulating recovery strategies emphasizing vaccination, social measures, and gradual resumption of air travel. Continuous monitoring of vaccination rates, air traffic, and preventive measures is vital for the Asian aviation industry's sustained recovery, ensuring safe travel while prioritizing public health.

Therefore, the compliancy of vaccination consumption and the achievement of herd immunity within countries in the Asian region with high vaccination rate have been crucial in determining the gradual recovery of the airline industries within the COVID-19 pandemic. Passengers' adherence to social measures are crucial to the success of international travel during the endemic phase, where they must comply with pre-departure testing requirements, vaccination certifications, and destination-specific guidelines. In addition, technological solutions, such as digital health passports, can facilitate the verification process and improve travel safety. The resumption of international travel necessitates continuous monitoring and adaptable strategies to strike a balance with public health concerns. Regular assessment of the epidemiological situation, vaccination coverage, and efficacy of social measures are essential for mitigating risks and modifying travel policies consequently. The COVID-19 endemic phase allows for the reopening of borders and the resumption of international travel. At the same time, public health and safety remain the most critical indicator for preventing reinfection with the virus.

Recommendations For Future Work

As the aviation industry continues to heal from the impacts of the COVID-19 pandemic, it is essential to conduct further research on the long-term effects of air traffic in the Asian region. The latter could involve analyzing the shifting travel patterns, passenger behaviors, and preferences in the aftermath of a pandemic. In addition, future research should evaluate the efficacy of the recovery measures implemented by airlines and regulatory organizations during the pandemic. Assessing the effect of health and safety protocols, travel restrictions, and government support programs on restoring passenger confidence and promoting air travel may be necessary by identifying successful strategies and best practices. As such, stakeholders may gain insight from past crises and challenges that have the potential to disrupt the aviation industry and implement them in the future. By comprehending these factors above, stakeholders in the aviation industry will be better equipped to navigate the challenges posed by the pandemic and for future potential disruptions.

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REFERENCES

[1] A.C. Wong. (2021), Vaccine nationalism: Rich nations must also care for the poor - https://www.lowyinstitute.org/the-interpreter/vaccine-nationalism-rich-nations-must-also-care-poor

[2] Abhishek D. (2020), Explained: India's Covid-19 air bubbles, and who can travel abroad - https://indianexpress.com/article/explained/india-air-bubbles-who-is-allowed-to-travel-to-these- countries-6605163/

[3] ACAPS. (2020), Report on government measures maps initial measures adopted by governments in response to the COVID-19 pandemic via https://www.acaps.org/covid-19-government-measures- dataset

[4] Bielecki. M, D. Patel, J. Hinkelbein, M. Komorowski, J. Kester, S. Ebrahim, A. J. Rodriguez-Morales, Z. A. Memish, P. Schlagenhauf. (2021), Air travel and COVID-19 prevention in the pandemic and peri-pandemic period: A narrative review, Travel Medicine and Infectious Disease, Volume 39, 2021, 101915, ISSN 1477-8939, https://doi.org/10.1016/j.tmaid.2020.101915.

[5] Chen, Zhang Q., Lu Y., Guo Z.M., Zhang X., Zhang W.J. (2020), Distribution of the COVID-19 epidemic and correlation with population emigration from Wuhan, China. Chin Med J (Engl). 2020. https://doi.org/10.1097/cm9.0000000000000782.

[6] Dou. (2020), Big data and smart aviation information management system, Cogent Business & Management. 7 (1), pp.1-14.

[7] E. Mathieu, H. Ritchie, L. Rodés-Guirao, C. Appel, C. Giattino, J. Hasell, B. Macdonald, S. Dattani, D. Beltekian, E. Ortiz-Ospina and M. Roser. (2020), "Coronavirus Pandemic (COVID-19)". Published online at OurWorldInData.org.

[8] E. Tarigan, V. Milko. (2021), Indonesia Starts Mass COVID Vaccinations Over Vast Territory https://thediplomat.com/2021/01/indonesia-starts-mass-covid-vaccinations-over-vast-territory.

[9] HAMID, M., Jam, F.A., Mehmood, S. (2019). Psychological Empowerment and Employee Attitudes: Mediating Role of Intrinsic Motivation. International Journal of Business and Economic Affairs, 4(6), 300-314.

[10] Hausladen, Iris and Schosser, Maximilian. (2020), Towards a maturity model for big data analytics in airline network planning, Journal of Air Transport Management, 82, issue C, https://EconPapers.repec.org/RePEc:eee:jaitra:v:82:y:2020:i:c:s0969699718304988.

[11] I. Stefano & N. Fabrizio & Satamaria, Carlos & Spyratos, Spyridon & V. Michele. (2020), Estimating and Projecting Air Passenger Traffic during the COVID-19 Coronavirus Outbreak and its Socio- Economic Impact.

[12] I. Twinn, N. Qureshi, D. Sebastian & M.L. Conde. (2020), The Impact of COVID-19 on Airports (IFC - International Finance\ Corporation).

[13] J. Geddie, A. Aravindan. (2020), "Singapore extends partial lockdown until June 1 as infections surge" https://www.reuters.com/article/health-coronavirus-singapore-extension-idINKBN223158

[14] J. Stacey. (2020), Tourism Policy Responses to the coronavirus (COVID-19) https://www.oecd.org/ coronavirus/policy-responses/tourism-policy-responses-to-the-coronavirus-covid-19-6466aa20/

[15] K. Kaiser, P. Krishnan & J. Morisset. (2021), Reopening international flights during COVID-19: a new real-time big data dashboard applied to Vietnam.

[16] K. Omar, Dhesi Baha Raja, Nur Asheila Abdul Taib, Nadia Rajaram, Jinat Ahmed, H.S. Arvinder- Singh, Siti Aisah Mokhtar, Alvin Kuo Jing Teo, Lidwina Edwin Amir, Michelle Chan, Yee Theng Quek, Choo-Yee Ting. (2022), Risk stratification and assessment framework for international travel and border measures amidst the COVID-19 pandemic - A Malaysian perspective, Travel Medicine and Infectious Disease, Volume 47, 2022, 102318, ISSN 1477-8939, https://doi.org/10.1016/j.tmaid.2022.102318

[17] Lee, A.-J., Park, T.-R. ., & Jwa, J.-W. . (2023). Analysis of Foot Traffic due to COVID-19 using Mobile Network Big Data. International Journal of Membrane Science and Technology, 10(1), 254-260. https://doi.org/10.15379/ijmst.v10i1.1453

[18] Lee, I. (2017). Big data: Dimensions, evolution, impacts, and challenges. Business Horizons, 60 (3), pp.293-303.

[19] M. Schäfer, M. Strohmeier, V. Lenders, I. Martinovic and M. Wilhelm (2022), "Bringing Up OpenSky: A Large-scale ADS-B Sensor Network for Research". In Proceedings of the 13th IEEE/ACM International Symposium on Information Processing in Sensor Networks (IPSN), pages 83-94, April 2014. The OpenSky Network via https://opensky-network.org

[20] N. Turak (2020). "Emirates Airline to temporarily suspend all passenger flights from March 25 as UAE halts all air travel" - https://www.cnbc.com/2020/03/22/emirates-airline-to-suspend-all- passenger-operations-by-march-25.html

[21] Odarchenko, R., Hassan, Z., and Zaman, A. (2019), Use of big data in aviation: New Opportunities, Use Cases, and Solutions. In T. Shmelova, Y. Sikirda, N. Rizun, D. Kucherov, & K. Dergachov (Eds.), Automated systems in the aviation and aerospace industries: Advances in Mechatronics and Mechanical Engineering (pp. 336-452).

[22] OECD (2020). Which countries are under lockdown - and is it working? https://www.telegraph.co.uk/new s/2020/03/29/lockdowcountries/.

[23] Peiris, Poon. (2008), Severe Acute respiratory Syndrome (SARS). In: Encyclopedia of virology; 2008. https://doi.org/10.1016/B978-012374410-4.00780-9

[24] Shah, A. U. M., Safri, S. N. A., Thevadas, R., Noordin, N. K., Rahman, A. A., Sekawi, Z., Ideris, A., & Sultan, M. T. H. (2020), COVID-19

outbreak in Malaysia: Actions taken by the Malaysian government. International journal of infectious diseases: IJID: official publication of the International Society for Infectious Diseases, 97, 108–116. https://doi.org/10.1016/j.ijid.2020.05.093

[25] Toh. (2020), Coronavirus: All short-term visitors barred from entering or transiting in Singapore from Monday, 11.59pm - https://www.straitstimes.com/singapore/health/coronavirus-all-short-term- visitors-barred-from-entering-and-transiting-in

[26] World Health Organization (2020), Situation reports. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports

[27] Zhong & Wang (2020), China Ends Wuhan Lockdown, but Normal Life Is a Distant Dream - https://www.nytimes.com/2020/04/07/world/asia/wuhan-coronavirus.html

DOI: https://doi.org/10.15379/ijmst.v10i2.1823