Airports and Emergency Planning
Measures Implemented to Prevent the Spread of COVID-19 and their Effectiveness

(Versão corrigida após defesa)

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Resumo

Os aeroportos estão sujeitos a inúmeras situações que podem vir a perturbar o seu habitual funcionamento. Dada a impossibilidade de impedir disrupções, em especial as de origem natural, os planos de emergência e de contingência são a melhor ferramenta que os aeroportos possuem para reagir de uma forma eficaz a qualquer acontecimento.

No final de 2019, surgiu uma doença infeciosa de causa incerta denominada de COVID-19. A elevada taxa de transmissibilidade e o número crescente de casos em todo o mundo forçaram os governos a implementar medidas para restringir a circulação, tais como confinamentos ou encerramentos de fronteiras. Estas medidas tiveram um impacto mais do que significativo no sector aeronáutico. Assim, registaram-se mínimos históricos no número de voos efetuados, levando a perdas históricas em toda a aviação.

A fim de analisar a implementação de medidas contra a COVID-19, foram realizadas entrevistas a peritos, bem como inquéritos ao público em geral (aqueles que tinham viajado de avião em 2021). Através desta recolha de dados foram tiradas conclusões interessantes, tais como o facto de a medida mais eficiente ter sido a utilização obrigatória de máscaras e a medida menos eficiente em termos de custos ter sido a tomada de temperatura, que acabou por ser abolida com passar do tempo.

Embora nenhuma medida por si só fosse suficientemente eficiente para lidar com a pandemia, a atenuação por níveis foi considerada eficiente. Embora houvesse peculiaridades em cada aeroporto aquando da implementação das medidas, houve uma normalização das medidas ao longo do tempo. Finalmente, embora a maioria dos aeroportos já apresentasse secções nos seus planos de contingência/emergência que tratavam de "emergências de saúde pública", não estavam preparados para lidar com uma crise pandémica como a COVID-19.

Palavras-chave

Planeamento de Emergência; Planeamento de Emergência dos Aeroportos; COVID-19; Disrupções; Impacto Económico; Medidas Implementadas.

Resumo Alargado

Ocasionalmente, o mundo experimenta perturbações que podem ser naturais ou induzidas pelo homem. Este tipo de perturbação pode ser muito prejudicial para a indústria aeronáutica, especialmente se não houver uma preparação ou uma metodologia previamente estipulada para lidar com ela. Do passado, podemos dar numerosos exemplos de situações de grande escala que afetaram negativamente aeroportos e companhias aéreas. Exemplos foram a SARS (Síndrome Respiratória Aguda Grave) em 2003, as erupções vulcânicas que ocorreram na Islândia em 2010 ou ainda o 11 de Setembro nos Estados Unidos da América em 2001. Contudo, nem todas as perturbações foram globais, pequenas perturbações como inundações ou ataques bombistas foram situações que exigiram uma resposta local adequada para minimizar o impacto na circulação de pessoas e bens.

A fim de preparar os aeroportos e as companhias aéreas a lidar com este tipo de situações, foram desenvolvidos e postos em prática planos de emergência/contingência aeroportuária. Por conseguinte, é extremamente importante assegurar que este planeamento de emergência esteja atualizado e cubra o maior número possível de perturbações. Estes planos são uma fração de um conceito maior denominado Sistemas de Gestão de Segurança (série de processos definidos, ao nível de toda a organização, que proporcionam uma tomada de decisão eficaz baseada no risco, relacionada com as suas operações quotidianas). Por outras palavras, é a gestão do risco e a procura de uma resposta adequada a todas as situações que se podem enfrentar durante as operações do dia-a-dia.

Uma vez que os seres humanos são essencialmente reativos a lidar com a adversidade em vez de terem um carácter preventivo, os grandes desenvolvimentos na segurança da aviação surgiram após grandes catástrofes. Outras grandes perturbações, como as verificadas e mencionadas anteriormente, alertaram as entidades responsáveis pelos protocolos de segurança e planos de emergência, que algumas das ações tomadas para lidar com as perturbações, estavam desatualizadas ou eram ineficientes e que eram necessárias mudanças. Além disso, os exercícios de emergência são de importância crucial na identificação de possíveis lacunas nos Planos de Emergência, pelo que é fundamental pô-los em prática de uma forma recorrente e realista, a fim de maximizar a sua eficiência.

Então, se o processo de planeamento nunca estiver completo e as perturbações levarem a mudanças nestes mesmos planos de emergência, será que as entidades estavam preparadas para lidar com uma situação pandémica? Estavam preparadas para lidar com a COVID-19 que está a devastar o mundo? Que medidas foram implementadas e quais foram as mudanças e lacunas nos planos de emergência operativos nesta altura?

Assim, no estado da arte, conceitos fundamentais como "planeamento de emergência", "planos de emergência", "gestão de emergências" e “planos de contingência” foram abordados, com importância relevante ao longo da dissertação. Foi também fornecida uma breve história de planeamento de emergência. Durante a segunda parte do estado da arte, foram apresentadas as quatro principais disrupções do tráfego aéreo até 2018, nomeadamente os ataques de 11 de setembro nos Estados Unidos, a epidemia da SARS com epicentro na China, a erupção de Eyjafjallajökull na Islândia e finalmente a epidemia MERS, que afetou principalmente o Médio Oriente. Esta contextualização esclareceu historicamente o autor sobre as principais disrupções do tráfego aéreo, a fim de lançar as bases para este estudo de caso específico, nomeadamente a pandemia de COVID-19. Para cada situação, foram registadas as medidas implementadas para lidar com a mesma, bem como as modificações feitas para prevenir / mitigar uma disrupção similar. No caso da epidemia resultante do vírus MERS-CoV, a implantação e as medidas para conter a transmissão da doença em aeronaves foram mais rápidas à luz das lições aprendidas durante a epidemia do SARS-CoV no início do milénio.

No caso de estudo desta dissertação, foi abordada em particular a crise pandémica da COVID-19. Assim, em finais de 2019, surgiu uma "pneumonia viral de causa desconhecida" na província de Wuhan, China, que mais tarde seria designada por COVID-19 e cujo vírus foi denominado SARS-CoV-2. Esta doença espalhou-se rapidamente pelo mundo, deixando um número interminável de pessoas infetadas e mortes, bem como cicatrizes graves na economia mundial em todos os seus sectores. Deste modo, a aviação não foi exceição, tendo sido mesmo um dos setores mais afetados devido à sua estreita ligação com o sector do turismo. Estes sectores foram os mais atingidos, em grande parte devido às restrições impostas pelos governos para conter as crescentes ondas de infetados. Embora a COVID-19 não esteja totalmente extinta, os programas de vacinação, especialmente nos países desenvolvidos, lançaram as bases para a possibilidade de um regresso à "nova normalidade" e, por conseguinte, para a recuperação económica global.

A fim de avaliar a capacidade de “avaliação de risco dos aeroportos”, foram conduzidas uma série de entrevistas com especialistas responsáveis pela gestão de aeroportos, mais

especificamente, as medidas e protocolos implementados para combater a COVID-19. As entrevistas visavam descobrir se os planos de emergência e contingência dos aeroportos estavam preparados para lidar com a crise pandémica ou se apresentavam lacunas que tinham de ser resolvidas. Além disso, as entrevistas visavam verificar a homogeneidade, ou a sua falta, na implementação de medidas contra a COVID-19. Por outro lado, os inquéritos destinavam-se essencialmente a verificar, do ponto de vista do utilizador, as principais alterações sentidas pelos passageiros. O objetivo era, portanto, ter uma ideia do impacto das medidas no dia-a-dia das operações dos aeroportos.

Após as entrevistas, emergiram algumas conclusões claras. Verificou-se que embora já existissem secções nos planos de emergência dos aeroportos com "emergências sanitárias", estas eram vagas e muito ineficientes para lidar com uma crise pandémica como a que surgiu no final de 2019. Alguns países, como Portugal, não dispunham de planos de contingência para lidar com a COVID-19, tendo, portanto, surgido o IROPS. Assim, as entidades reguladoras responsáveis, juntamente com outros organismos, tais como o ministério da saúde ou os responsáveis pelos aeroportos, têm vindo a atualizar esses planos, em função da evolução da pandemia e do aparecimento de tecnologias mais eficientes, como o certificado de vacinação, para a deteção de potenciais casos positivos à SARS-CoV-2. Do mesmo modo, algumas das medidas adotadas revelaram-se pouco rentáveis, o que levou os aeroportos a aboli-las. Os casos mais comuns foram os pontos de controlo da temperatura e a desinfeção da bagagem. Concluiu-se então que a deteção de portadores do vírus só era possível através de "atenuação em camadas", uma vez que nenhuma medida por si só provou ser o suficientemente eficaz.

Economicamente falando, a COVID-19 levou à maior perturbação do tráfego aéreo da história, atingindo perdas sem precedentes. No sector da aviação houve um maior impacto no transporte de passageiros em relação à carga, bem como um maior impacto no mercado doméstico em comparação com o internacional. Por conseguinte, espera-se que os sectores menos afetados sejam os primeiros a recuperar, com as previsões a apontar para 2024-2025 para o sector da aviação no seu conjunto.

Da mesma forma, chegaram-se a algumas conclusões ao analisar os dados recolhidos a partir dos inquéritos. Assim, foram registadas 300 respostas, das quais apenas 186 foram consideradas válidas (pessoas que viajaram efetivamente de avião em 2021). De um modo geral, nos mais de 90 aeroportos por onde passaram os passageiros inquiridos, observou-se uma ampla implementação de medidas para combater a propagação da SARS-CoV-2. De facto, existiram medidas grandemente implementadas e adotadas pelos passageiros como o uso obrigatório das máscaras e utilização de dispensadores de álcool

em gel. Contudo, nestes inquéritos também foram registadas medidas pouco implementadas e menos eficientes, como por exemplo a desinfeção das bagagens, e a existência de casas de banho dedicadas aos membros da tripulação.

Relativamente aos pontos de controlo da temperatura e tendo em conta que nenhum dos 186 inquiridos mostrou febre, conclui-se que este método revelou ser muito ineficiente, justificando a sua abolição (como se viu nas entrevistas). Devido a esta situação, não foi possível inferir o modo de atuação por parte dos aeroportos aquando da deteção de um potencial caso positivo a SARS-CoV-2. A apresentação do certificado de vacinação ou PCR negativo, assim como distanciamento social foram duas medidas amplamente adotadas pelos aeroportos e pelas transportadoras aéreas. Finalmente, foi observado que a implementação de medidas, não interferiu demasiado no tempo de trânsito dos passageiros.

Durante a realização deste trabalho, foram encontradas algumas limitações, especialmente em relação às entrevistas e inquéritos e à dificuldade em obter respostas em todo o mundo. Assim, as perspetivas para o trabalho futuro são as seguintes:

- Expandir as entrevistas, de forma a abranger a totalidade dos continentes com o intuito de verificar se as diferenças culturais e geográficas influenciaram as medidas implementadas em todo o mundo.
- Incluir pequenos aeroportos ou mesmo aeródromos que possam ter encerrado durante a crise pandémica ou nos primeiros meses de confinamento, a fim de verificar se a sua estratégia seria ou não mantida no caso de uma nova crise.
- Realizar entrevistas com transportadoras aéreas a fim de incluir os seus pontos de vista nas medidas implementadas contra a COVID-19.
- Tendo em conta a nacionalidade do autor e a sua rede de contactos, a maioria dos inquiridos viajou no continente europeu. Outra perspetiva de trabalho futuro seria alargar o inquérito a todos os continentes, a fim de verificar a homogeneidade ou não das opiniões e sensações vividas, independentemente dos locais de partida e chegada.
- No final da pandemia, verificar o impacto económico total, bem como o cumprimento das perspetivas de recuperação económica para 2024-2025.
- Na eventualidade de uma nova crise pandémica para além da COVID-19, verificar se as medidas foram implementadas de uma forma mais rápida e eficaz. Verificar também se os planos de contingência nessa altura estarão adequadamente preparados para lidar com as perturbações sem a necessidade de implementar medidas alternativas.

Abstract

Airports are subject to numerous situations that can disrupt their normal operations. Given the impossibility of preventing disruptions, especially those of natural origin, emergency and contingency plans are the best tool airports have to react effectively and quickly to any event.

In late 2019, emerged an infectious disease of uncertain cause named COVID-19. The high rate of transmissibility and the increasing number of cases worldwide forced governments to implement measures to restrict movement, such as confinements or border closures. These measures had a more than significant impact on the aeronautical sector, which was one of the most affected. Record lows were thus recorded in the number of flights made, leading to historic losses throughout aviation.

In order to analyse the implementation of measures against COVID-19, interviews were conducted with experts as well as surveys of the general public (those who had travelled by air in 2021). Through this data collection, interesting conclusions were drawn, such as the fact that the most efficient measure was the mandatory use of masks, which was widely adopted worldwide, and the least cost-efficient measure was the temperature plug, which was eventually abolished at most airports over time.

Although no single measure on its own was efficient enough to deal with the pandemic, tiered mitigation was considered efficient. Although there were peculiarities at each airport when the measures were implemented, there was a normalization of measures over time. Finally, although most airports already had sections in their contingency/emergency plans that dealt with "public health emergencies", they were not prepared to deal with a pandemic crisis like COVID-19.

Keywords

Emergency Planning; Airport Emergency Planning; COVID-19; Disruptions; Economic Impact; Measures Implemented.

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List of Acronyms

SARS	Severe Acute Respiratory Syndrome
MERS	Middle East Respiratory Syndrome
IROPS	Irregular Operations
AEP	Airport Emergency Planning
PCR test	Polymerate Chain Reaction test
CCTV cameras	Closed-Circuit Television Cameras
USA	United States of America
RPMs	Revenue Passenger Mile
TSA	Transport Security Administration
ID	Identify Document
CoV	Coronavirus
RPKs	Revenue Passenger Kilometer
ICAO	International Civil Aviation Organization
IATA	International Air Transport Association
WHO	World Health Organization
CAAS	Civil Aviation Authority of Singapore
PIC	Pilot-in-Command
VEI	Vulcanic Explosiveness Index
IAVW	International Airways Volcano Watch
IVATF	International Volcanic Ash Task Force
SRA	Safety Risk Assessment
UAE	United Arab Emirates
ROK	Republic of Korea
HEPA filters	High Efficiency Particulate Air
APU	Auxiliary Power Unit
SEF	Serviço de Estrangeiros e Fronteiras
ANAC	Administración Nacional de Aviación Civil
UV	Ultraviolet
CANAERO	Cámara Nacional de Aerotransportes
GACA	General Civil Aviation Authority
PHE	Public Health Emergency

Chapter 1 - Introduction

1.1 Motivation

Airports are vulnerable to any number of scenarios that could diminish their ability to maintain smooth operations. Each of these scenarios presents a potential for loss, whether that be loss of life, money, reputation, or a combination of all of them [1].

From time to time, the world experiences disruptions that can be either natural or human induced. This type of disturbance can be very harmful to the aeronautical sector, especially if there is no preparation or a methodology previous stipulated to deal with it. From the past, we can give numerous examples of situations on a large scale that have negatively affected airports and airlines. Examples of this were SARS (Severe Acute Respiratory Syndrome) in 2003, volcanic eruptions that took place in Iceland in 2010 or September the 11^{Th} in the United States of America in 2001. But not all disruptions were global, minor disturbances like floods or bomb attacks are situations that need an adequate response to minimize the impact on circulation. If an airport suffers repeated disruption, loss of confidence may drive clients (airlines, businesses, passengers, etc.) to search for other alternatives [1] which is something that should to be avoided.

In order to prepare airports and airlines to deal with this type of situations, Emergency/Contingency Plans have been developed and implemented. An Airport Emergency Planning is the process of preparing an airport to deal with an emergency occurring at the airport or in its vicinity. The target of airport emergency planning is to minimize the effects of an emergency, namely in respect of saving lives and maintaining aircraft operations [2]. Therefore, it is extremely important to ensure that this emergency planning is up-to-date and that covers as many disruptions as possible. These plans are a fraction of a larger concept called Safety Management Systems (series of defined, organization-wide processes that provide for effective risk-based decision-making referred to your daily business [3]). In other words, it is risk management and the quest to provide an adequate response to all situations that someone may face during the day-to-day operations.

As the human being is essentially reactive in dealing with adversity instead of having a preventive nature, the major developments in terms of safety and security in aviation came after big disasters. It is common sense that the September the 11, brought some

important safety improvements, both in the daily management of airports (100 ml limitation in all bottles travelling in the cabin and major updates in the security checkpoints), and in the aircraft constructions (reinforced, bullet-proof doors became usual for most of the world's airlines [4] and some aircrafts were also equipped with CCTV cameras, so the pilots can monitor cabin activity) and thus prevent a similar event from happening again. Other major disruptions, such as those seen in the previous paragraph, alerted the entities responsible for safety protocols and emergency plans that some of the actions taken to deal with that disturbances were out of date or inefficient and that changes were needed. In addition, emergency exercises are of crucial importance in identifying possible flaws present in the Emergency Plans, which is why it is crucial to put them into practice in a recurring and realistic manner in order to maximize their efficiency.

Being prepared for the type of situations or emergencies that an aeronautical administration can face, not only it can save lives, which is the major objective of this safety protocols, but it will also save money. How can an emergency plan save money at airports or airlines? If there is a pre-stipulated and efficient way to deal with a disturbance, an airport can avoid closing facilities by confining the threat to a specific location and continuing to operate, as far as possible, in another sector of that airport. In this sense, the airport will be able to minimize the impact on circulation and, thus, minimize the economic impact associated with flights cancellations or delays, in other words, reduce the monetary losses of the airlines correlated to a closed airspace. In addition, if the emergency plan is well defined, overlaps will be avoided and the response time will be optimized, which may lead to a minimization of the consequences of the emergency or, if not possible, to a quicker return to the normal traffic flow for that same airport. If a major event happens — recovery is the immediate aim, and 'normality' is the target [1]. Finally, if human lives are in danger, a good emergency plan will increase the likelihood of saving lives, which, of course, will reduce economic compensations to the victims' families, safeguarding the reputation of both the airport and the airline.

Due to the fact that the overall flow of air traffic, in 15 years accordingly to [5], increased from 1994 million passengers in 2004 to 4543 million in 2019, i.e., more than doubled the number of passengers, expansions in old airports were needed and new small airports were built to accommodate that growth. Airport emergency planning is thus getting more and more attention, because even a small event has a huge impact on the finances of the airport operator nowadays [6]. Therefore, it is increasingly important to properly manage these events, but what does it mean to have "successfully managed" an event? An emergency event is 'successful' when the number of casualties is minimized; when

the loss of property is minimal; when panic is contained; when media reports are quite fair, calm and controlled; and when businesses can return to normal operations within a 'reasonable', ideally predefined, period of time [1].

If the current Emergency Plan has been able to "successfully managed" the event that the airport has been going through, means that no (major) changes are necessary and that, at least for that specific event, the plan is efficient. Otherwise, if the plan has not reached the highest point of efficiency possible, changes must be made and improvements must be implemented within the available resources. Adjustments have been made in the past, as seen before, and will be made in the future because no plan is perfect and flaws will always be present.

Emergency planning may be conceived and implemented as a process. It is a continuing pattern of revisions, as well as opportunities for the development and maintenance of individual and team performance skills achieved through training, drills and critiques [7]. So, if the planning process is never complete [8] and disruptions lead to changes in these same emergency plans, were the entities prepared to deal with a pandemic situation? Were they prepared to deal with COVID-19 that is devastating the world? What were the measures implemented and what were the changes and the failures presented in the operational emergency plans operative at that time? These are the questions that this thesis intends to answer, as shown more specifically in the section bellow.

1.2 Object and Objectives

The object of this thesis are the emergency/contingency plans and their efficiency. As told before, the objective of airport emergency planning is to minimize the effects of an emergency, in particular with regard to saving lives and maintaining aircraft operations. The airport emergency plan highlights the procedures for coordinating the response of different airport agencies (or services) and those agencies in the surrounding community that could be of help in responding to the emergency [2].

In the past, numerous situations and disruptions have shown the world that the aviation sector was not always fully prepared to deal with this type of threat and that adjustments were needed to ensure passengers safety with the least possible impact on daily operations. Thus, particularly in this paper, it will be analysed how some specific airports were prepared when COVID-19 emerged and whether there was adequate legislation and procedures in the face of such a threat, how airports dealt with this specific disruption,

what measures were implemented and whether they were the same in different parts of the world or whether cultural differences led airports to follow different strategies.

In addition, the economic impact of the pandemic on airports will be analysed in this paper. Finally, the effectiveness of these same measures will be examined taking into account the economic effort as shown in the methodology.

In short, the object are the emergency plans and their efficiency and the objectives are to analyze the measures implemented to deal with COVID-19 and their effectiveness, as well as the cost of the referred implementations.

1.3 Methodology

The methodology of this work will have, essentially, a qualitative type of approach in the analysis of the emergency plans and their efficiency in dealing with this threat known as COVID-19. However, a quantitative analysis will also be done at the end.

This investigation will start by analysing the major disruptions that the air transportation has dealt in the history in order to settle the basis to the case of study. In that way, it is therefore imperative to analyse, not only the impact in the sector but also the measures and the procedures put in place to deal with that specific disruption. So, in the state of art, the lecturer will be presented with a brief resume of the four major disruptions (the September 11 attacks, the SARS, the Eyjafjallajökull eruptions and the MERS), in chronological order. In order to simplify the understanding of the areas of affectation a table will be presented as well. The same will be done for the COVID-19 in chapter 3.

Afterwards, interviews will be performed within specialist and competent entities about the measures put in place worldwide to sustain the spread of the COVID-19. The focus of this interviews, beyond the measures currently on the ground, will be to analyse the efficiency of those and if other safety actions could be put in practice. In addition, a series of surveys will be carried out in order to verify the impact of the measures implemented, from the passengers' point of view.

Finally, but not least, a quantitative approach will be taken. This last part will focus on quantifying, for each chosen airport, the monetary and operational costs of airports during the pandemic.

Figure 1 summarizes the relationship among Dissertation Structure (by chapter) and Methodology used to achieve the desired objectives.

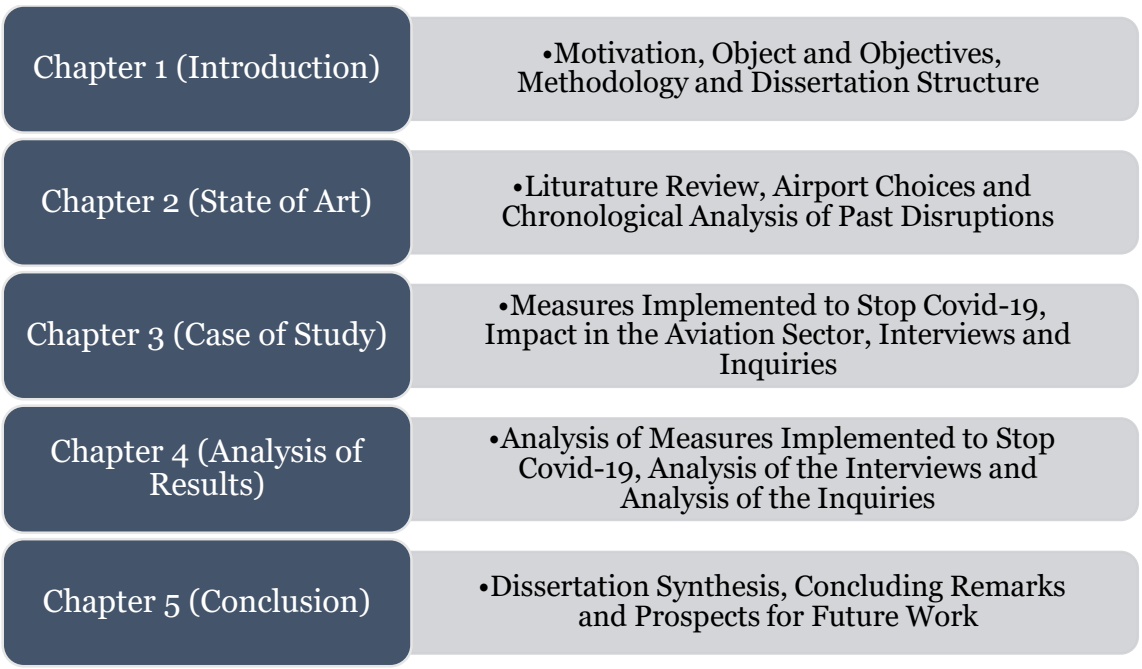


Figure 1 - Relationship among Dissertation Structure and Methodology

1.4 Dissertation Structure

The structure of this thesis will be divided into five chapters. First, will be presented the introduction which will contain the motivation, the object and the objectives, the key words as well as the methodology and the thesis structure. This first chapter will allow the reader to locate himself and have an overall preview about the work present in this paper.

The second chapter of this document will be dedicated to the state of art where will be address to the analysis of the proper literature concerning emergency/contingency plans and a chronological analysis of past disruptions, in order to settle the basics to the case of study.

In the third chapter will be present the case of study that will be performed accordingly to the orientations available in the methodology.

Analysis of results will comprise chapter 4. In this section will be analysed the questions brought up in the Introduction, taking into account the data collected from the interviews and the inquiries.

Finally, chapter 5 will conclude the dissertation synthesis along with limitations found, concluding remarks, and prospects for future work within this field.

Chapter 2 – State of Art

As mentioned in the methodology, this chapter will address the concept of Emergency Planning and Contingency Plans, with its objectives, content, as well as its implementation. It will also be done, an historical contextualization of this same concept, in order to make its importance in today's society more explicit.

We will then move on to the concept of Emergency Management, its connection with emergency planning and its different phases/parameters. Finally and more specifically, we will talk about the Airport Emergency Plans, a central theme in the course of this dissertation and an integral part of the so-called literature review, in the methodology.

After this concepts familiarization, we will be presented with an explanatory table of the choices made at the level of the airports under study, with a brief explanation of the four biggest air traffic disruptions to date, their impact and lessons learned. We will then analyse the changes that have occurred in the procedures resulting from these crises.

2.1 Concepts

What is an Emergency/Contingency Planning?

As seen before, emergency plans and procedures should be established to ensure that there will be an appropriate response to unexpected or accidental incidents. The organization should define and keep procedures for dealing with environmental incidents and potential emergency situations [9].

The objectives of these plans are as follows:

- Prevent fatalities and injuries;
- Reduce damage to buildings, stock, and equipment;
- Protect the environment and the community;
- Accelerate the resumption of normal operations.

Development of the plan begins with a vulnerability assessment. The results of the study will show:

- How likely a situation is to occur;
- What means are available to stop or prevent the situation;

- What is necessary for a given situation;
- From this analysis, appropriate emergency procedures can be established.

At the planning stage, it is important that the relevant individuals or groups be asked to participate. Members of the team can include:

- employees with knowledge of the work;
- supervisor of the area or work;
- safety officer;
- health and safety committee;
- union representative, if applicable;
- employees with experience in investigations;
- "outside" experts;
- Representative from local government, police, fire, or ambulance.

The emergency plan should count on external resources, such as the police, firemen or ambulances, each of these entities must be consulted when carrying out the plan and a joint response must be coordinated. In order to ensure the efficiency of the response, communication actions, training and periodic exercises must be performed [10].

An emergency/contingency plan must contain the following issues:

- All possible emergencies, consequences, required actions, written procedures, and the resources available;
- Detailed lists of emergency response personnel including their cell phone numbers, alternate contact details, and their duties and responsibilities;
- Floor plans;
- Large scale maps showing evacuation routes and service conduits (such as gas and water lines).

What are the roots of Emergency/Contingency Planning?

Natural disasters are recurrent in the past, present and future of humanity. From its foundations, humanity has been subjected to adversities of natural origin and, more recently, of human induced (for example, terrorism). As a result, over the centuries, the need to create protective mechanisms to respond to these tragedies has emerged. Thus, procedures were created and certain actions were taken, namely emergency plans (although extremely rudimentary) to deal with these catastrophes.

Emergency plans played an important role during World War I, especially after the attacks on Guarnica and Pearl Harbor, where their ineffectiveness left hundreds dead. Thus, first emergency plans were just a codification of common sense, but over the years they evolved in efficiency and complexity, becoming the object of work for specialists and professionals. If during World War I the objective was to protect populations from bombing or radioactive leaks, they are used today in countless fields, with innumerable objectives. For example, in aviation, to ensure safe flights for passengers.

Over the years, emergency plans have become more professional. The figure of the commander (essentially military) has given way to that of coordinator who, instead of improvising, has the function of managing resources and assigning areas of intervention to the participating entities (firemen, police, medical personnel...). Thus, modern emergency plans are more a work of cooperation between entities than a chain of command, always guaranteeing a sense of responsibility.

Historically, emergency situations have been used to introduce oppressive ideas, such as confining minorities to ghettos in the name of greater security. Therefore, it is essential not to distinguish between genders and adapt plans for people with disabilities [11].

What is Emergency Management?

Emergency management is the managerial function charged with creating the framework within which communities reduce vulnerability to hazards and deal with disasters. Looks to promote safer, less vulnerable communities with the capacity to cope with hazards and disasters" [12].

Emergency Management and Emergency Planning are closely linked because any emergency plan is based on the phases that constitute disaster management. Thus, the four parameters/phases mentioned are as follows:

- Mitigation;
- Preparedness;
- Reaction;
- Recovery [13].

In this parlance, mitigation is seen as prevention of stopping a negative event before it occurs. A common example is to use "breach proof" containment for hazardous substances as a way of preventing accidental environmental releases during the transportation process [14].

Preparedness represents actions that are undertaken to reduce the negative consequences of events where there is insufficient human control to institute mitigation measures. For example, evacuation planning is a preparedness measure usually used to protect vulnerable populations from riverine flooding [15].

Response refers to actions undertaken immediately before and during impact to reduce primary and secondary negative effects. Ideally, response measures are conceived as preparedness, but some part of them seem to be inevitably devised spontaneously [16].

Finally, recovery measures cover what has traditionally been called reconstruction and recovery; ultimately the rebuilding of the disaster-impacted entity [17].

What is an “Airport Emergency Plan”?

More specifically, this work concerns airport emergency plans. Thus, the airport emergency plan aims to specify, in a manual, the procedures to be followed in the event of an airport emergency.

The emergency types are divided as follows according to [2]:

- Emergencies involving aircraft:
    - Accident – aircraft on-airport
    - Accident – aircraft off-airport
        - Land
        - Water
    - Incident – aircraft in flight
        - Severe air turbulence
        - Decompression
        - Structural failure
    - Incident – aircraft on ground
    - Incident – sabotage including bomb threat
    - Incident – unlawful seizure
- Emergencies not involving aircraft:
    - Fire – structural
    - Sabotage including bomb threat
    - Natural disaster
    - Dangerous goods
    - Medical emergencies
- Compound emergencies:

- Aircraft/structures
- Aircraft/fuelling facilities
- Aircraft/aircraft

Likewise, aircraft emergencies are classified according to the following definitions and based on [2]:

- “aircraft accident”: an aircraft accident which has occurred on or in the vicinity of the airport;
- “full emergency”: an aircraft approaching the airport is, or is suspected to be, in such trouble that there is imminent danger of an accident;
- “Local standby”: an aircraft approaching the airport is known or is suspected to have developed some defect, but the trouble is not such as would normally involve any serious difficulty in effecting a safe landing.

Depending on the type and classification of the emergency, different procedures are implemented. Although standardized by flight regulatory agencies, each airport has its own procedures, due to its characteristics and layout. Depending on its location, it may be more sensitive to some emergencies than others. Take the example of John F. Kennedy International Airport (JFK) in New York (USA), located on the waterfront, which is much more susceptible to flooding than Daocheng Yading Airport in China, located 4411 meters above sea level. Precisely and due to its altitude, the Chinese airport, located in the Himalayas, is more sensitive to strong winds than the American airport. In short, if there is a “modus operandi” for emergency plans at airports, each airport must have its emergency plan adapted to its local reality.

2.2 Disruptions and their Area of Affectation

In this subsection, a summary table (Table 1) of the disturbances mentioned above is presented. This table is designed to more easily identify the most interesting areas of the globe and then choose the target airports for analysis. Please note the following notation:

Y: Area affected by disruption

+/-: Area little affected by disruption

N: Area unaffected by disruption

Table 1 - Disruptions and their area of affectation

	September the 11	SARS	Eyjafjallajökull Eruption	MERS	Covid-19
North Europe	+/-	+/-	Y	+/-	Y
Central Europe	+/-	+/-	Y	+/-	Y
East Europe	+/-	+/-	Y	+/-	Y
South Europe	+/-	+/-	+/-	+/-	Y
North America	Y	Y	+/-	+/-	Y
Centre America	+/-	N	N	N	Y
South America	+/-	N	N	N	Y
North Africa	+/-	N	N	+/-	Y
West Africa	+/-	N	N	N	Y
East Africa	+/-	N	N	N	Y
Central Africa	+/-	N	N	N	Y
Southern Africa	+/-	+/-	N	N	Y
Middle East	+/-	N	N	Y	Y
Central Asia	+/-	N	N	N	Y
South Asia	+/-	+/-	N	+/-	Y
East Asia	+/-	Y	N	Y	Y
Southeast Asia	+/-	Y	N	+/-	Y
Oceania	+/-	+/-	N	N	Y
Antarctica	N	N	N	N	N

2.3 Major Disruptions in Aviation History

2.3.1 September the 11th

September 11 attacks, also called 9/11 attacks, a serial of airline hijackings and suicide attacks performed in 2001 by 19 militants (all died during the attack) associated with the Islamic extremist group Al-Qaeda against targets in the United States, the deadliest terrorist attacks on American soil in U.S. history. The attacks against New York City and Washington, D.C., caused major destruction and death and triggered an enormous U.S. effort to combat terrorism. 2,750 people were killed in New York, 184 at the Pentagon, and 40 in Pennsylvania (where one of the hijacked aircrafts crashed after the passengers attempted to retake the plane). Police and fire departments in New York were especially hard-hit: hundreds had rushed to the scene of the attacks, and more than 400 police officers and firefighters died [18].

According to [19]:

“On September 11, 2001, at 8:45 a.m. on a clear Tuesday morning, an American Airlines Boeing 767 loaded with 20,000 gallons of jet fuel crashed into the north tower of the World Trade Centre in New York City. The impact left a gaping, burning hole near the 80th floor of the 110-story skyscraper, instantly killing hundreds of people and trapping hundreds more in higher floors. As the evacuation o/f the tower and its twin got underway, television cameras broadcasted live images of what initially appeared to be a freak accident. Then, 18 minutes after the first plane hit, a second Boeing 767 — United Airlines Flight 175 — appeared out of the sky, turned sharply toward the World Trade Centre and sliced into the south tower near the 60th floor. The collision caused a massive explosion that showered burning debris over surrounding buildings and onto the streets below. It immediately became clear that America was under attack.

The hijackers were Islamic terrorists from Saudi Arabia and several other Arab nations. Reportedly financed by the al Qaeda terrorist organization of Saudi fugitive Osama bin Laden, they were allegedly acting in retaliation for America’s support of Israel, its involvement in the Persian Gulf War and its continued military presence in the Middle East. Some of the terrorists had lived in the United States for more than a year and had taken flying lessons at American commercial flight schools. Others had slipped into the country in the months before September 11 and acted as the “muscle” in the operation. The 19 terrorists easily smuggled box-cutters and knives through security at three East Coast airports and boarded four early-morning flights bound for California, chosen because the planes were loaded with fuel for the long transcontinental journey. Soon

after take-off, the terrorists commandeered the four planes and took the controls, transforming ordinary passenger jets into guided missiles.

As millions watched the events unfolding in New York, American Airlines Flight 77 circled over downtown Washington, D.C., before crashing into the west side of the Pentagon military headquarters at 9:45 a.m. Jet fuel from the Boeing 757 caused a devastating inferno that led to the structural collapse of a portion of the giant concrete building, which is the headquarters of the U.S. Department of Defence. All told, 125 military personnel and civilians were killed in the Pentagon, along with all 64 people aboard the airliner.

Less than 15 minutes after the terrorists struck the nerve centre of the U.S. military, the horror in New York took a catastrophic turn when the south tower of the World Trade Centre collapsed in a massive cloud of dust and smoke. The structural steel of the skyscraper, built to withstand winds in excess of 200 miles per hour and a large conventional fire, could not withstand the tremendous heat generated by the burning jet fuel. At 10:30 a.m., the north building of the twin towers collapsed. Only six people in the World Trade Centre towers at the time of their collapse survived. Almost 10,000 others were treated for injuries, many severe.

Meanwhile, a fourth California-bound plane — United Flight 93 — was hijacked about 40 minutes after leaving Newark Liberty International Airport in New Jersey. Because the plane had been delayed in taking off, passengers on board learned of events in New York and Washington via cell phone and air phone calls to the ground. Knowing that the aircraft was not returning to an airport as the hijackers claimed, a group of passengers and flight attendants planned an insurrection. The passengers fought the four hijackers and are suspected to have attacked the cockpit with a fire extinguisher. The plane then flipped over and sped toward the ground at upwards of 500 miles per hour, crashing in a rural field near Shanks Ville in western Pennsylvania at 10:10 a.m. All 44 people aboard were killed. Its intended target is not known, but theories include the White House, the U.S. Capitol, and the Camp David presidential retreat in Maryland or one of several nuclear power plants along the eastern seaboard.

A total of 2,996 people were killed in the 9/11 attacks, including the 19 terrorist hijackers aboard the four airplanes. Citizens of 78 countries died in New York, Washington, D.C., and Pennsylvania. At the World Trade Centre, 2,763 died after the two planes slammed into the twin towers. That figure includes 343 firefighters and paramedics, 23 New York City police officers and 37 Port Authority police officers who were struggling to complete an evacuation of the buildings and save the office workers trapped on higher floors. At

the Pentagon, 189 people were killed, including 64 on American Airlines Flight 77, the airliner that struck the building. On Flight 93, 44 people died when the plane crash-landed in Pennsylvania.

Operation Enduring Freedom, the American-led international effort to oust the Taliban regime in Afghanistan and destroy Osama bin Laden's terrorist network based there, began on October 7. Within two months, U.S. forces had effectively removed the Taliban from operational power, but the war continued, as U.S. and coalition forces attempted to defeat a Taliban insurgency campaign based in neighbouring Pakistan. Osama bin Laden, the mastermind behind the September 11th attacks, remained at large until May 2, 2011, when he was finally tracked down and killed by U.S. forces at a hideout in Abbottabad, Pakistan. In June 2011, then-President Barack Obama announced the beginning of large-scale troop withdrawals from Afghanistan.

In the wake of security fears raised by 9/11 and the mailing of letters containing anthrax that killed two and infected 17, The Homeland Security Act of 2002 created the Department of Homeland Security. It was signed into law by President George W. Bush on November 25, 2002. Today, the Department of Homeland Security is a cabinet responsible for preventing terror attacks, border security, immigrations and customs and disaster relief and prevention. The act was followed two days later by the formation of the National Commission on Terrorist Attacks upon the United States. The bipartisan "9/11 Commission," as it came to be known, was charged with investigating the events that led up to September 11th. The 9/11 Commission Report was released on July 22, 2004. It named Khalid Sheikh Mohammed, the accused mastermind behind 9/11, "the principal architect of the 9/11 attacks."

The 9/11 attacks had an immediate negative effect on the U.S. economy. Many Wall Street institutions, including the New York Stock Exchange, were evacuated during the attacks. On the first day of trading after the attacks, the market fell 7.1 percent, or 684 points. New York City's economy alone lost 143,000 jobs a month and $2.8 billion wages in the first three months. The heaviest losses were in finance and air transportation, which accounted for 60 percent of lost jobs. The estimated cost of the World Trade Centre damage is $60 billion. The cost to clean the debris at Ground Zero was $750 million."

No industry has suffered greater economic damage from the terrorist attacks of September 11, 2001 than the U.S. airline industry. The airline industry was particularly impacted because commercial aircrafts were the weapon used by the terrorists in the attacks against the World Trade Centre and the Pentagon. In the immediate aftermath of the attacks, the U.S. government, for three days, grounded the commercial fleet what

resulted in a 31.6% reduction in travel volume in September of 2001 compared to that same month in 2000 and generated massive industry losses [20]. In addition to directly causing a temporary but complete shut-down of the commercial aviation system, the attacks caused a massive reduction of air travellers, caused by a newly-perceived risk associated with flying [21]. It took about six years for airlines to recover capacity after the 9/11 terrorist attacks.

In Figure 2 there is a graphical representation of the drop in RPMs (Revenue Passenger Mile) after the September the 11^{th} attacks in USA.

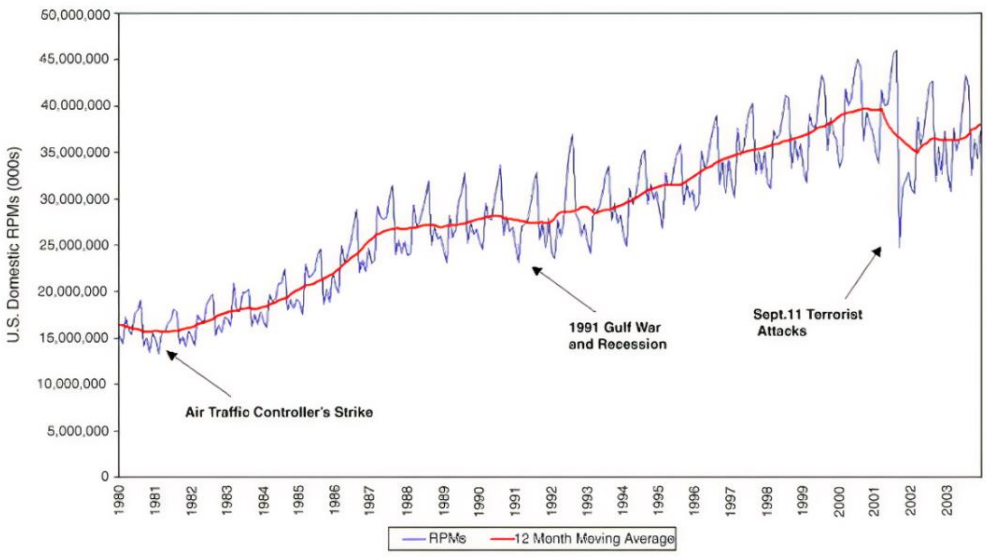


Figure 2 - US Domestic RPMs. Source: adapted from [21].

In addition to these monetary losses, security measures were implemented. These measures were not only aimed at preventing hijackings from happening again, but also at regaining passenger confidence.

The United States, Europe Union, Canada, and a lot of other countries redesigned their aviation security sectors after 9/11. USA spends the biggest cash in aviation security, but as a whole, the European Union is not far behind. Since 9/11, USA has spent over $100 billion in aviation security [22].

The following were aspects of security prior to the 9/11, according to [23]:

- Private companies, not the government, oversaw airport screening;
- Were permitted blades up to 4 inches (10 cm) on the plane;
- Baseball bats, box cutters, darts, and scissors were also permitted on the plane;

- Family members were able to go through security to the departing gate to say goodbye;
- Passengers could keep shoes on when going through security;
- Passengers were able to carry liquids on to the plane;
- Metal detector was the only security screening;
- No ID was required;
- Passengers would only need to arrive 30 minutes before their flight to ensure that they would make their flight.

Failures were found in the airport security system, which led to a certain amount of changes. In this way, the following are aspects of U.S. security post-9/11, according to [24]:

- The government, oversaw airport screening;
- An official ID must be presented that matches the name on the ticket;
- No liquids larger than 3.4 ounces (100 ml) are allowed on the cabin of plane;
- Extensive X Ray screening for all baggage;
- The TSA made cockpit doors more secured;
- Passengers are either screened by a metal detector or a Millimetre Wave Scanner;
- Family members are no longer able to go through security and to the departing gate;
- Passengers need to arrive upwards of 3 hours before international flights and at least 1.5 hours before domestic flights to ensure proper boarding.

Thus, some of the technologies used today in airports are as follows, as per [22]:

- Metal Detectors;
- Millimetre Wave Scanners;
- 2D X-Rays for carry-on bag screening;
- CT scanners for checked baggage;
- Use of canines and manual searches.

On the other hand, listed below are some of the technologies that are expected to be implemented in the near future, according to [25]:

- Enhanced 3D Computed Tomography (CT) Scanners;
- Automated Screening Lanes;
- Biometric Fingerprint Identification.

In short, on September 11th, the most mediatised disorder, which claimed the greatest number of victims in the history of aviation, took place in the United States of America. Since then, a large monetary effort has been made in order to mitigate the risk of hijacking and the use of aircraft as a weapon. Thus, several areas such as screening of passengers, cabin baggage, and hold baggage, airport security, aircraft security, screening of cargo and mail, screening of airport supplies and staff recruitment and training, were improved using new techniques and equipment.

2.3.2 Severe Acute Respiratory Syndrome (SARS)

Severe acute respiratory syndrome (SARS) is a viral respiratory disease caused by a SARS-associated coronavirus. It was first identified at the end of February 2003 during an outbreak that emerged in Guangdong province of China, the disease was transmitted with great rapidity to Australia, Brazil, Canada, China, Hong Kong, South Africa, Spain and the USA [26]. It was the first severe and readily transmissible new disease to emerge in the 21st century and showed a great capacity to spread along the routes of international air travel [27].

The SARS pandemic was eventually brought under control in July 2003, following a policy of isolating people suspected of having the condition and screening all passengers travelling by air from affected countries for signs of the infection. During the period of infection, there were 8,098 reported cases of SARS and 774 deaths. This means the virus killed about 1 in 10 people who were infected. People over the age of 65 were particularly at risk, with over half of those who died from the infection being in this age group.

In 2004 there was another smaller SARS outbreak connected to a medical laboratory in China. It was thought to have been the result of someone coming into direct contact with a sample of the SARS virus, rather than being caused by animal-to-human or human-to-human transmission [28]. Since 2004, there have not been any known cases of SARS reported anywhere in the globe [29].

The following table (Table 2) shows the number of SARS cases and the number of deaths due to the same disease by country during the health crisis. Data presented here is provided by WHO.

Table 2 - Reported SARS Cases by Country

China	Hong Kong	Taiwan	Canada	Singapore
5327	1755	346	251	238
Vietnam	USA	Philippines	Thailand	Mongolia
63	27	14	9	9
Germany	France	Australia	Malaysia	Sweden
9	7	6	5	5
Italy	UK	India	Korea	Indonesia
4	4	3	3	2
Macau	Kuwait	New Zealand	Ireland	Romania
1	1	1	1	1
Russia	South Africa	Spain	Switzerland	
1	1	1	1	

For a more intuitive understanding, the following map was created. Figure 3 shows the incidence of SARS-CoV in the world.

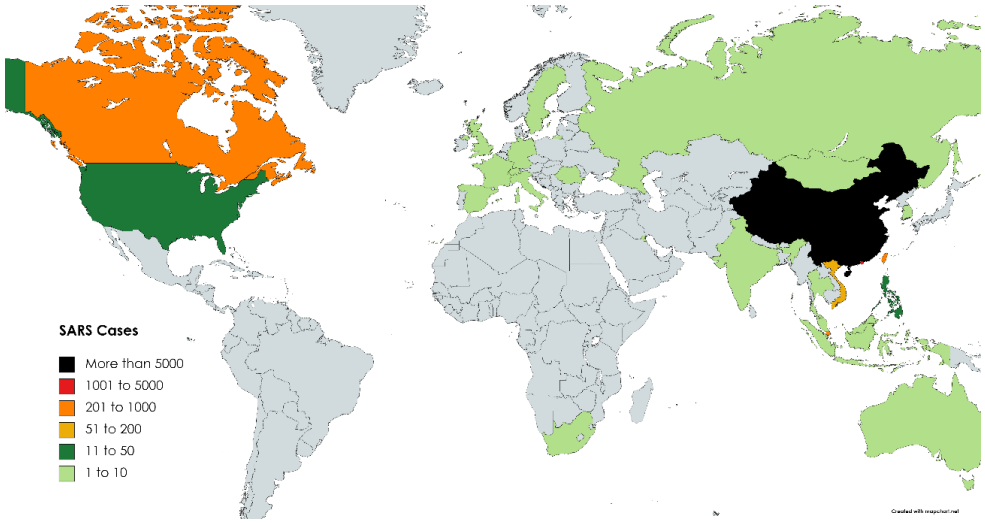


Figure 3 - Reported SARS cases in the world

SARS is an airborne virus and can spread through small droplets of saliva in a similar way to the cold and if someone else breathes in the droplets, they can become infected. Can also be spread indirectly if an infected person touches surfaces like door handles with unwashed hands. Someone who touches the same surface may also become infected. Evidence from the SARS pandemic of 2002 to 2003 showed people caring for someone or living with a known SARS infection were most at risk of developing the infection themselves [28]. The syndrome is characterized by high fever, cough and

respiratory distress (labored breathing, shortness of breath). SARS was provoked by a coronavirus (CoV) that is an animal virus from bats which infected human in China [30].

What is the correlation between this disease and the aviation industry? Being an airborne and highly contagious disease, closed spaces with poor air circulation are ideal places for massive transmission of the disease.

It is well known that in the case of aircrafts, where hundreds of people are concentrated in closed cabins for a long period of time, the probability of contagion increases dramatically, despite the air conditioners that recirculate the air. Also, the non-use of masks in people's pre-pandemic daily lives, as well as the lack of systematic disinfection of aircraft's bathrooms, facilitated the spread of the disease. Another decisive factor for the spread of the virus had to do with the shift towards globalization and the consequent increase in air traffic in our daily lives. This explained the ease of transmission of the disease on a global scale, the difficulty of containing it and the fact that cases of infected SARS-CoV have been reported in all continents.

SARS was the most serious epidemic disease impacting traffic volumes in the recent period, before COVID-19. At the height of the outbreak (May 2003), monthly RPKs of Asia-Pacific airlines were 35% lower than their pre-crisis levels. Overall in 2003, the loss of confidence and fear of global spread impacted both business and leisure travel, from and within the region, resulting in Asia-Pacific airlines losing 8% of annual RPKs and $6 billion of revenues [31].

Under the auspices of ICAO (International Civil Aviation Organization), an international working group met in Singapore between 2003 June the 2nd and the 4th. Members of the group were medical representatives of ICAO, WHO (World Health Organization), IATA (International Air Transport Association), CAAS (Civil Aviation Authority of Singapore), Ministry of Health of Singapore, and the chief physician of Tan Tock Seng Hospital (designated SARS hospital for Singapore) as well as airport officials from CAAS. The aim of the meeting was to develop a set of adequate anti-SARS protective measures to be implemented at international airports in SARS-affected areas. Appropriate guidelines for inspectors were also implemented [32].

Also according to [32] the measures implemented to deal with this threat were the following ones:

- An airport public health emergency official has been appointed as responsible for the implementation of all SARS protective measures. This person, who is not necessarily a physician, coordinates the SARS protective measures at the airport.
- Warning is given (e.g. posters, public announcements) to crew and passengers before or immediately on entering the airport premises that no one with symptoms of SARS will be allowed to board any flight.
- Screening of departing passengers for SARS symptoms is undertaken in accordance with WHO recommendations. This is accomplished by:
    - Asking, as a minimum, the three WHO questions, of all departing passengers, preferably before but no later than at check-in
    - Objective temperature measurement by a reliable method such as thermal imaging, infrared measurement or the use of thermometers (oral or axillary with disposable sheaths, aural with disposable caps, sublingual strips, forehead fever strips).
    - If any of the WHO questions are answered positively and/or if the temperature reading exceeds 37.5 degrees, the passenger is isolated and evaluated by a designated health care provider.
    - A passenger who is coughing is provided with a face mask.
    - If the secondary screening determines that the person in question is a possible case of SARS, then the person has to undergo a medical examination and assessment by a qualified medical practitioner.
    - If the medical practitioner determines that the said person is well and does not meet the WHO SARS suspect case definition, the person is allowed to continue the voyage.
    - If the medical practitioner determines that the said person meets the suspect SARS case definition, the person is taken to the designated SARS hospital.
    - If the person does not meet the SARS case definition but the medical practitioner determines that the person is ill, continuation of the voyage may only be allowed after the usual IATA procedures for such cases have been followed (submission of the medical information form to the airline's medical service).
- Disembarking passengers arriving from affected areas are normally screened by responding to questionnaires, completed during the flight or at the latest,

immediately upon disembarkation. These questionnaires are reviewed at the time of disembarkation. Passengers offering positive responses are referred for secondary screening.

- All passengers are provided with information about SARS symptoms and the appropriate public health contact numbers if available.
- Procedures are in place to respond to the arrival of an aircraft with a possible SARS case on board. These procedures are:
    - Formal questions to be asked of the pilot-in-command (PIC) of the arriving aircraft (number of passengers involved, their symptoms, and time of onset of symptoms).
    - Information to be provided to the PIC: where to park (usually away from the jet-bridge), no disembarkation of ill passenger/s until medical clearance, which doors to open.
    - In the eventuality that a sick passenger has to be removed from the aircraft before being medically assessed, removal to a designated isolation area should await the arrival of the medical practitioner. In this situation all infection control measures are to be employed including personal protective equipment for persons in close contact with the passenger.
    - A sick passenger (meeting the WHO SARS suspect case definition) should be removed directly from the aircraft, without passing through arrival areas used by other passengers. Only if direct removal is impossible should other procedures be employed. In all cases, contact with other passengers and airport staff must be minimized.
    - Airport management and designated public health authorities are immediately alerted.
    - Passengers and crew from this flight are segregated until contact information is obtained and passengers and crew have been advised of the precautionary measures necessary
        - Procedures are in place for Immigration and Customs clearance of ill passengers taken directly from the arriving aircraft.
        - The necessary infection control measures are implemented by the airport authorities.
- All airport workers are subject to daily temperature screening at the beginning of their work shift.
- Workers are reminded by posted information or other means of their obligation not to report to work if they are unwell.

As far as air traffic is concerned, we thus conclude that travel restrictions are essential to limit the geographic reach of an epidemic, even though it involves the difficult balance between public health, human rights and economic interests. Further, the marginal public health benefit from ratcheting up restrictions may not be predictable. Under the intense pressure of the SARS outbreak, many countries were forced to adopt novel approaches to population risk assessment and disease containment, including thermal screening to identify febrile persons at risk for SARS. News of the global SARS epidemic caused the voluntary restrictions of international travel to affected areas. Travel advisories and travel alerts from WHO and individual countries helped to provide timely and accurate information [33].

2.3.3 Eyjafjallajökull Eruption

On April 14, a volcanic eruption occurred in Iceland. One of the many active volcanoes present on this Atlantic Island caused a disruption in international air traffic that directly affected most European countries. In addition to Portugal, Malta, Greece, Albania, Northern Macedonia, Cyprus and Turkey, all other countries completely closed their airspace during the interruption period, as we can see in Figure 4.

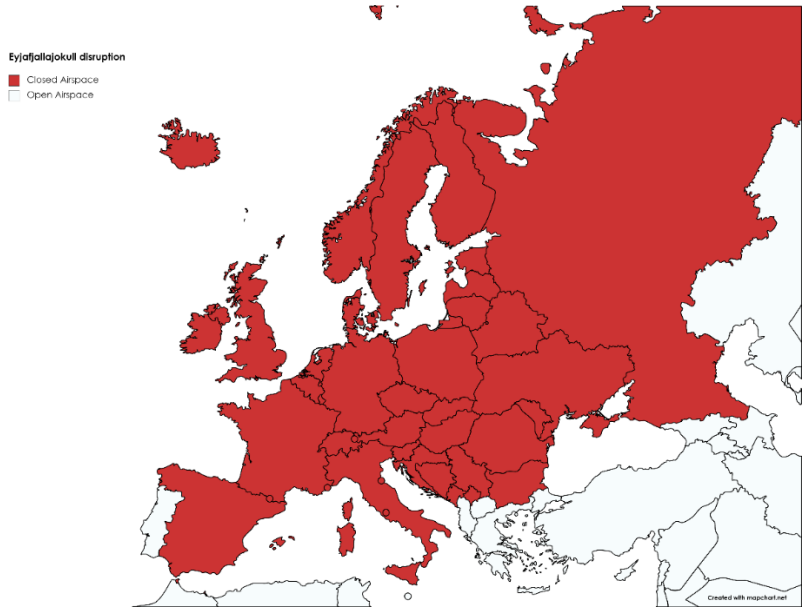


Figure 4 - Affected Countries by Eyjafjallajökull disruption

Initially, the notions of “volcanic ash” and “volcanic cloud” will be presented. Thus, volcanic ash is a comprised of minerals unique to the volcanic eruption. Minerals common to most volcanic ash are silica together with smaller amounts of the oxides of aluminium, iron, calcium and sodium. The glassy silicate material is very hard and extremely abrasive. Its melting point is below jet engine burner temperature which introduces additional hazards according to [34]. And a volcanic cloud is the sum of the

material ejected from a volcano into the atmosphere and transported by winds aloft. It comprises volcanic ash, gases and chemicals also as per [34].

Therefore, the question arose: Why did this eruption had such a huge impact on the aviation sector? Three factors must be considered to answer this question:

- Eyjafjallajökull is located under a glacier, which means that above the crack opening there are 200 meters of ice and snow. When the eruption began, the extremely high temperatures of the magma in the chamber (1000°C) began to melt the glacier. These large blocks of cold ice fell into the chamber causing the magma to cool very quickly, breaking this flow into extremely small pieces of rock we call ash. That was the reason for the huge amount of ash present in this eruption. 250 million cubic meters of tephra were produced during this phenomenon.
- The Volcanic Explosiveness Index (VEI) was highly increased due to the enormous amount of frozen water in the top of the volcano. Expanding gases from the rapid vaporization of ice started a series of moderate photo magmatic bursts (which result from the contact of water and magma) that sent a plume of steam and ash almost 7 miles (11 km) into the atmosphere [35]. This same index reached 4 out of 8 on the VEI scale.
- The geographic location of Eyjafjallajökull played an important role in the massive disruption of air traffic, as a jet stream is usually located above it. The jet stream is a core of strong winds around 5 to 7 miles above the Earth's surface, blowing from west to east [36]. The strongest jet flows are polar jets with an altitude of between 9km-12km. In this particular case, the polar jet stream remained quite stable during the six days after the eruption began and was responsible for transporting all that ash far from its point of origin, contaminating European airspace.

The ice above the volcano generated very light and fine ash and also increased the rate of explosiveness, allowing that same ash to reach the high point where a very stable and powerful jet streamed towards Europe (Figure 5). The combination of these three factors was the reason for this massive disturbance.

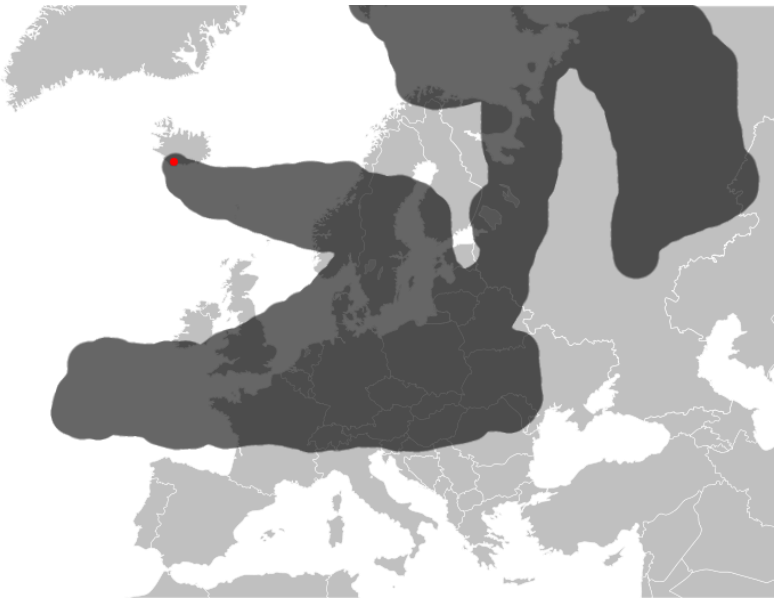


Figure 5 - Eyjafjallajökull disruption jet stream. Source: adapted from [37].

But, what is the relationship between this ash cloud and the huge disruption of air traffic? The airspace was closed essentially due to the fact that this same ash is highly harmful to the plane and pilotage.

When an aircraft is enveloped into a cloud of ash, the vision of the pilots is greatly impaired, even to the point where they rely exclusively on measuring devices to guide themselves. Furthermore, the integrity of the aircraft is also called into question for two reasons. Firstly, because this cloud of debris will damage the skin of the aircraft, leading to irreversible deformations and damaging its aerodynamics. Secondly, because the ash will be "sucked" into the engine along with the surrounding air being housed. Due to the high temperatures present in the propulsive system, this ash (which is nothing more than a powder) will melt and create a superficial layer of rock. When thick enough, this layer will interrupt the engine's normal air flow and greatly impair its cooling, changing the air/fuel ratio that combustion should take place inside the chamber. In this way and depending on the exposure time and the composition of the ash, it can lead to failure of the propulsive systems and their irreversible damage.

Thus, in addition to monetary losses caused by engine degradation and aircraft's exterior deformations, there may also be associated loss of life resulting from engine failures. Reason why all flights within the contaminated airspace were cancelled.

An example of an aircraft affected by volcanic ash was a scheduled British Airways flight from London Heathrow to Auckland, with stops in Bombay, Kuala Lumpur, Perth, and Melbourne in 1982. The aircraft flew into a cloud of volcanic ash ejected by the eruption of Mount Galunggung south east of Jakarta in Indonesia, resulting in the failure

of all four engines [38]. During the following sixteen minutes, the aircraft descended without power from FL370 to FL120, at which point the flight crew was able to successfully restart engines one, two and four after which an ongoing diversion was made to Jakarta. Subsequent strip-down inspection of the engines found general evidence of “sand-blasting”, erosion of compressor rotor paths and rotor blade tips, erosion of the leading edges of high-pressure rotor blades and fused volcanic debris on the high pressure nozzle guide vanes and turbine blades. It was concluded that the engines on the aircraft had all stalled following the ingestion of a significant quantity of volcanic ash and that a restart had only been reached because the aircraft, in descending without power, emerged from ash cloud into clear air with sufficient terrain clearance [39].

Historically, it is known that whenever Eyjafjallajökull erupts, the seismic activity of another volcano, called Katla, begins in months afterward. O Kalta is one of the major volcanoes in Iceland, with a diameter of 10 km and its previous eruptions always showing a volcanic explosiveness index between was 4 in 2010. Both distance is barely 25 km, part of the same glacier and found by the same jet stream, which contaminated the European skies in 2010. For comparative analysis purposes, it should be remembered that while the last big eruption of Katla, 6000-7000 thousand m3 of tephra were expelled. In 2010 there were 250 million m3 expelled by Eyjafjallajökull. It is therefore urgent to raise awareness about the importance of preparing the aeronautical sector for this type of incident.

As expected, an increase in seismic activity took place in the vicinity of the Katla after the 2010 event leading to a sub glacial eruption in 2011. Cracks in the ice were noted and the melting of part of the glacier resulted in a flood that led to the destruction of a small bridge located on the outskirts of the volcano. In 2016 and 2017, earthquakes were recorded with magnitudes of 3.0 and 4.5 respectively, on the Richter scale, however without any eruption.

Volcanic eruptions are recurrent events in Iceland, due to its geographical location between two tectonic plates, namely the Eurasian plate and the North American plate, as shown in figure 6. Due to the nature of the boundary between the plates and the formation of a new crust, it is called the "Divergent Limit" where the plates move away from each other. Therefore, Iceland is in a process of continuous and never-ending growth, due to the sedimentation of lava from volcanic eruptions and where periodic incidents similar to that of Eyjafjallajökull should be expected.

Figure 6 - Iceland tectonic plates and Eyjafjallajökull location. Source: adapted from [40].

However, not all tectonic plate boundaries are "Divergent Boundaries" as is the case in Iceland or even in the Democratic Republic of Congo. Effectively, when it comes to countries like Japan, Chile, Papua New Guinea and the Philippines, we talk about "Converging Limits" which are also strategic places prone to this type of disruption. On the other hand, the "Transforming Limits", where plates move laterally in opposite directions, such as the San Andreas Fault in California, are not of relevant importance for this study, as they do not originate volcanoes and consequently risk of eruption.

Thus, there are two types of volcanoes: those of the type "Composite Volcanos", located in Covering Boundaries and those of the type “Shield Volcanos", located in Divergent Boundaries. The first type is more dangerous, as it has higher explosive levels with a higher concentration of ash and volcanic gases. It also has a thicker magma, due to its lower temperature and longer periods between eruptions. Given its geographical location, both Eyjafjallajökull and all other volcanoes in Iceland are of the second type, namely “Shield Volcano”. Therefore, the worst scenario would be an eruption of a volcano of the first type, in the same conditions as Eyjafjallajökull, which is, covered by a glacier and under a constant jet flow, which takes the ash to a high density zone of air traffic.

On an economic level and according to the International Air Transport Association (IATA) lost revenues now total more than $1.7 billion for airlines alone. At the worst, the crisis impacted 29% of global aviation and affected 1.2 million passengers a day. The scale of the crisis overtook 9/11 when US airspace was closed for three days [41]. In addition

to the losses suffered by airlines, there were large losses in the tourism sector, that amounted to between 7-9 million USD. Several economic activities, at the world level, were harmed by this disruption, however alternative means of transport to aviation such as rail or land transport ended up being the main beneficiaries.

Finally, in order to prevent and mitigate the negative effects of a volcanic eruption such as Eyjafjallajökull, the “International Civil Aviation Organization” (ICAO) created two offices, namely “International Airways Volcano Watch” (IAVW) and “International Volcanic Ash Task Force (IVATF)" with the purpose of analysing the propensity to fly close to ash and its impact on aircraft. Another target was to facilitate the delimitation of circulation zones. In the case of a volcanic eruption, it was therefore possible to avoid the total closure of the airspace, while ensuring safety in flight, in accordance with [42].

Thus, there were several measures implemented in the years after the 2010 eruption, to prepare airlines, air traffic management and stakeholders, to act appropriately in the event that similar events occur again. These measures are presented below:

- Creation of three levels of security, still in the initial phase and along the crisis. Thus, affected or dangerous areas may be defined into various levels of volcanic ash contamination such as the low, medium and high contamination thresholds currently being used in Europe according to [34].
- Improved cooperation and enhanced trust between European agencies to make European airspace more unified and better able to handle international incidents.
- For aircraft operators to decide whether or not to fly in ash-contaminated airspace, a safety risk assessment (SRA) must be established, stipulating safety procedures when encountering volcanic ash in flight. The SRA must be approved by the operator’s national aviation administration for the operator. As of November 2016, the majority of European nations mutually recognise the SRA [43].
- Conduction of data collection flights with the aim of measuring the effects of ash on aircraft and more specifically on their engines. These flights still took place during the disruption and were fundamental, since until then the ash resistance tests carried out by engine manufacturers were rare and imprecise. It should be said that these were carried out without the approval of insurance companies and many of them were in charge of the airlines.
- Installation of light detectors and range sensors or lidars, in the following years, both on aircraft and on top of European mountains, in order to solve one of the

major problems highlighted during the crisis, i.e., the difficulty in detecting accurately, the concentration of ash in the air.

- Carrying out several works in order to increase the prediction efficiency of these models. Modelling of volcanic ash plumes was one of the fundamental themes in the years following the eruption of Eyjafjallajökull. These models aim to efficiently predict the contamination zones and volcanic ash concentrations in order to delimit the airspace, in the three security levels seen above. Variables such as wind orientation and intensity or ash density are taken into account when simulating. Sustainable progress has been made in the detection of volcanic ash from meteorological satellite data, especially data in certain of the infrared wavelengths, and the forecasting of volcanic ash cloud trajectories using computer models [44].
- Regulation changes were also made. It went from 0.2 mg/m^3 maximum concentration of ash in air for safe flight, (values stipulated before disruption), to 2 mg/m^3 in the reopening phase of European airspace and finally to 4 mg/m^3 within six days of the onset of the rash. These are the values currently stipulated by "engine builders" and are believed to be conservative values.
- Conducting a simulation of a European airspace contamination scenario with a duration of two days, in order to update the contingency plans for this type of incident. This simulation was carried out after modifications made to the regulations, as seen in [45].

2.3.4 Middle East Respiratory Syndrome (MERS)

Middle East respiratory syndrome coronavirus (MERS-CoV) is a virus transmitted to humans from infected dromedary camels. It is a zoonotic virus, meaning it is transferred between animals and people, and can be contracted through direct or indirect contact with infected animals. MERS-CoV has been identified in dromedaries in many countries in the Middle East, Africa and South Asia [46].

The origins of the virus are not fully understood but according to the analysis of different virus genomes it is believed that it may have originated in bats and later transmitted to camels at some point in the distant past. Human-to-human transmission is possible, but only a few such transmissions have been found among family members living in the same household. In health care settings, however, human-to-human transmission appears to be more frequent.

In total, 27 countries have reported cases since 2012, leading to 858 known deaths due to the infection and related complications. Approximately 35% of patients with MERS-CoV succumbed, but this may be an overestimate of the true mortality rate, as mild cases of MERS may be missed by existing surveillance systems. The case fatality rates are currently counted only amongst the laboratory-confirmed cases [46].

The following table shows the number of MERS cases as well as the number of cases due to the disease by country during the health crisis. Data presented is provided by [47].

Table 3 - Reported MERS Cases by Country

Saudi Arabia	Korea	UAE	Jordan	Qatar
2176	186	92	28	23
Oman	Iran	UK	Kuwait	Thailand
24	6	5	4	3
Germany	Tunisia	Lebanon	Philippines	Malaysia
3	3	2	2	2
Netherlands	France	Austria	USA	Algeria
2	2	2	2	2
Yemen	Bahrain	China	Turkey	Italy
1	1	1	1	1
Greece	Egypt			
1	1			

For a more intuitive understanding, the following map was created. Figure 7 shows the incidence of MERS-CoV in the world.

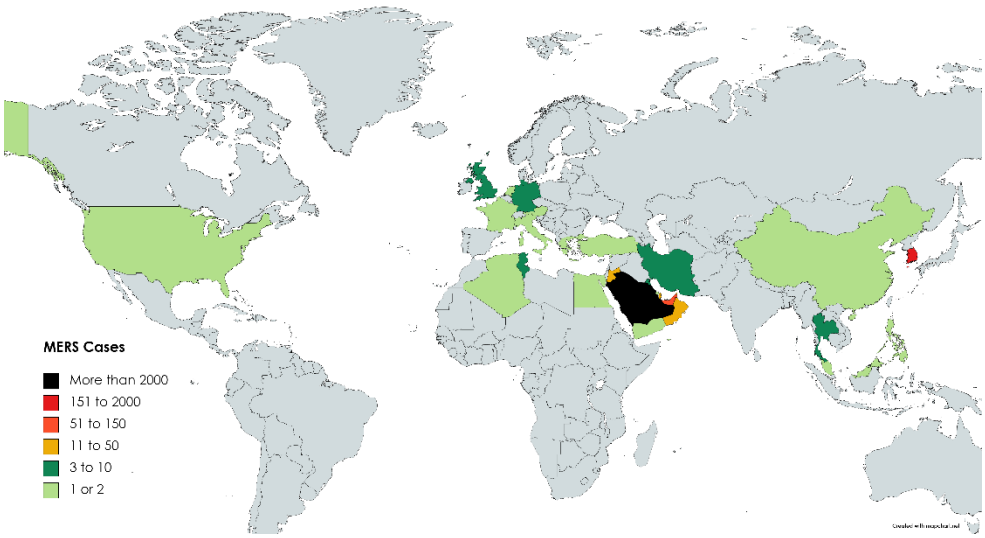


Figure 7 - Reported MERS cases in the world

MERS-CoV infections range from showing no symptoms (asymptomatic) or mild respiratory symptoms to severe acute respiratory disease and death. Even thought, a typical presentation of MERS-CoV disease is fever, cough and shortness of breath. Pneumonia is a common finding, but not always present and gastrointestinal symptoms, including diarrhoea, have also been reported. Severe illness can cause respiratory failure that requires mechanical ventilation and support in an intensive care unit. The virus appears to cause more severe disease in older people, people with weakened immune systems and those with chronic diseases such as renal disease, cancer, chronic lung disease, and diabetes.

MERS-CoV human cases result from primary or secondary transmission. Primary transmission is classified as transmission not resulting from contact with a confirmed human MERS case-patient and can result from zoonotic transmission from camels or from an unidentified source. Among cases classified as primary by the WHO, only 191 (54.9%) individuals reported contact with dromedaries. Secondary transmission is classified as transmission resulting from contact with a human MERS case-patient, typically identified as healthcare-associated or household-associated, as appropriate [48]. MERS-CoV, like other coronaviruses, likely spreads from an infected person's respiratory secretions, such as through coughing [49].

Regarding of MERS Flu, which was focused more on a single country, the first impact was a sharp slowdown, i.e., a 12% decline in monthly RPKs to, from and within South Korea in the first month of the outbreak. However, air travel volumes began to recover after two months and had returned to pre-outbreak levels within 6 months [31]. Real per capita GDP decreased by 16% in Saudi Arabia, 25 % in Qatar, 12% in the UAE and 32% in Kuwait [50].

As with SARS-CoV, there is an intrinsic relationship between MERS-CoV and the aeronautical industry. Thus, due to the fact that it is also transmissible by air and secretions, the recirculation of air in closed spaces, as in the case of aircraft cabins, must be avoided. If during the pandemic period, SARS-CoV warned of the need to disinfect surfaces and wear masks on board, these reflexes are naturally abolished over time, which leads to greater ease in transmitting the virus. Another problem is related to the increase in international air circulation, which explains the presence of the pathogen (MERS-CoV) on a global scale.

Also like with SARS-CoV, prevention measures were implemented during the MERS-CoV pandemic. According to [51] they were as follows.

Regarding airports:

- Temperature controls, although not mandatory, were recommended in order to avoid possible infected passengers at the departure airport. If shown signs of fever, a second measurement should be taken. If the second measurement confirms the first, the passenger must be taken to an appropriate location for inspection.
- Systematic disinfection of certain areas, especially handrails, wrists or areas susceptible to touch.
- Clear instructions to staff and passengers, not to appear at the airport in case of symptoms without penalty in the case of the staff and using incentives with regard to passengers (for example, rebooking of the boarding ticket at no additional cost or full refund of the cost of the same).

Regarding airlines:

- Assured disinfection of aircraft after each landing
- Reservation of a bathroom for the exclusive use of the crew (closest to the cockpit)
- Limited movement inside the cabin.
- Personalized treatment: if a passenger with symptoms is identified after take-off, he is isolated from his household (even if asymptomatic), and the member of the crew who was closest or who had contact with the patient, be the one who provides him with personalized services until his disembark.
- Notification of the situation before landing: disembarkation must be done in accordance with the instructions of the responsible authorities.
- Activation of the bureaucratic procedure: if the passenger tests positive for MERS-CoV, the contact list of people who were within a 2-row radius is provided by the airline in order to be tested and quarantined. If, on the other hand, the passenger tests negative, it will not be necessary to implement the above measures.

It should be remembered that one of the countries most affected by MERS-CoV was the Republic of Korea. Despite being severely affected, the rapid implementation of the containment measures led to the outbreak's control in 2015.

What lessons has this country learned and how it has prepared for the recent Covid-19 pandemic?

The MERS outbreak served as a chance for extensive health education to the general public and health workers. Thanks to the repetitive communication of information through multiple channels, the general public learned about the importance of washing hands, wearing a face mask, maintaining respiratory etiquette, and practicing social distancing during the MERS-CoV outbreak [52]. Also, hospitals learned that insufficient IPC could severely impact hospital management and finance. They gained institutional knowledge about how to set up MERS-CoV screening stations [53]. On the other hand, practices in IPC at emergency departments were improved. More general rooms were created at Emergency Medical Centres [54]. Hospitals were also encouraged to redesign emergency removes to create separate spaces and enable physical distancing between patients.

Moreover, the country had an opportunity to test and further refine its preparedness soon after the first MERS outbreak. On September 9, 2018, the first MERS-CoV case after the 2015 outbreak was detected in the ROK [55]. The patient, who arrived from the Middle East, visited a hospital on the day he arrived at the airport. The case was immediately confirmed as MERS-CoV infection at the hospital. The government immediately convoked a press conference and coordinated a nationwide answer. The rapid response team identified 21 close contacts and 487 casual contacts, all of whom were monitored and quarantined. There were no secondary transmissions reported [56].

In short, measures such as regular use of masks, hand hygiene, social distancing, quarantine and PCR tests were implemented in order to combat the rapid transmission of the virus. Although MERS-CoV has not had the same impact as Covid-19 globally, lessons have been learned and put into practice as seen above. Thus, it was noted, especially in countries with larger outbreaks of MERS-CoV, greater preparedness and therefore a faster and more efficient response to the latest pandemic.

2.4 Conclusions

As part of this work, fundamental concepts were approached, such as “Emergency Planning”, “Emergency Plans” and “Emergency Management”, with relevant importance throughout the dissertation, having been familiarized with the author. A brief history of emergency planning was also provided.

In the second part of the state of the art, the 4 biggest interruptions in air traffic until 2018 were presented, namely, the September 11 attacks in the United States, the SARS epidemic with an epicentre in China, the eruption of Eyjafjallajökull in Iceland and

finally the MERS epidemic, which mainly affected the Middle East. This contextualization has historically elucidated the reader as to the main disturbances in air traffic, in order to lay the foundations for this specific case study, namely the Covid-19 pandemic.

For each situation, the measures implemented to remedy the disturbance were observed, as well as the modifications made to prevent / mitigate a new disturbance. In the case of the epidemic caused by the MERS-CoV pathogen, implementation and measures to contain the transmission of the disease in airplanes were faster due to the lessons learned during the SARS-CoV epidemic at the beginning of the millennium.

Chapter 3 – Case of Study

The case study of this dissertation specifically addresses the measures implemented at airports and aircraft to combat Covid-19, namely the procedures adopted to hinder the spread of the disease. Results obtained from interviews and surveys carried out for this purpose will also be presented in this chapter.

In the first part of the case study, an introduction to COVID-19 will be given, and issues such as its origin, how it spreads, symptoms, the number of infected and deaths to date, as well as the relationship of the disease to the aviation industry and its economic impact will be addressed.

In order to assess the ability of airports to find the balance point, effectiveness against the cost of the measures implemented to stop COVID-19, several interviews will be carried out with experts as well as inquiries to people used to travel by plane, i.e., target-public. Issues such as the prior existence of emergency plans to deal with infectious diseases, or the economic and operational impacts on certain airports will be addressed in this same section of the thesis.

3.1 Introduction to COVID-19

According to [57] the coronavirus is an infectious disease caused by the SARS-CoV-2 virus. Even if there are cases of infected people requiring hospitalization, most infected people recover at home. Elderly people and people with underlying medical conditions, such as cardiovascular disease, diabetes, chronic respiratory disease, or cancer, are more likely to develop serious illnesses. Although the groups described above are the most at risk, all infected people can experience severe symptoms or even die at any age.

COVID-19 started in an open-air “wet market” in Wuhan Province, China. “Wet markets” are normally large collections of open-air stalls selling fresh seafood, meat, fruits, and vegetables. Some wet markets sell and slaughter live animals on site, including chickens, fish, and shellfish. In China, they’re the basis of everyday life for many according to [58]. Sometimes some of these markets sell wild animals that are killed on the spot, as was the case in Wuhan market.

In this way, issues of hygiene and quality control are often overlooked or ignored, which resulted in zero patient infection. The term “wet” stands for a large amount of fluids in this type of market, whether the origin is from the tanks in which the marine animals are found, or from the blood of recently killed animals [58].

Although the origin of the disease is not entirely clear, scientists believe that SARS-CoV-2 originated in bats in the image of SARS-CoV. However, taking into account that at that time bats were not being sold at the Wuhan market, it is believed that patient zero was infected through a pangolin that had been previously infected by a bat.

SARS-CoV-2 affects people in a variety of ways, with most symptomatic people presenting mild to moderate symptoms and recovering without recourse to hospitalization. There are also asymptomatic people who, despite being carriers of the virus, do not show any symptoms. Thus, according to [57], we have:

Most common symptoms:

- Fever;
- Cough;
- Tiredness;
- Loss of taste or smell.

Less common symptoms:

- Sore throat;
- Headache;
- Aches and pains;
- Diarrhoea;
- A rash on skin, or discolouration of fingers or toes;
- Red or irritated eyes.

Serious symptoms:

- Difficulty breathing or shortness of breath;
- Loss of speech or mobility, or confusion;
- Chest pain.

On average it takes 5–6 days from when someone is infected with the virus for symptoms to show, however it can take up to 14 days.

Until the present day (15/01/2022) the number of cases in the world due to COVID-19 is 325084751 and the number of death is 5550419, which gives a death ration of 1,71%. Figure 8 shows the distribution of COVID-19 cases in the world (15/01/2022). Both the data above and the data to build Figure 8 and Figure 9 was collected in [59].

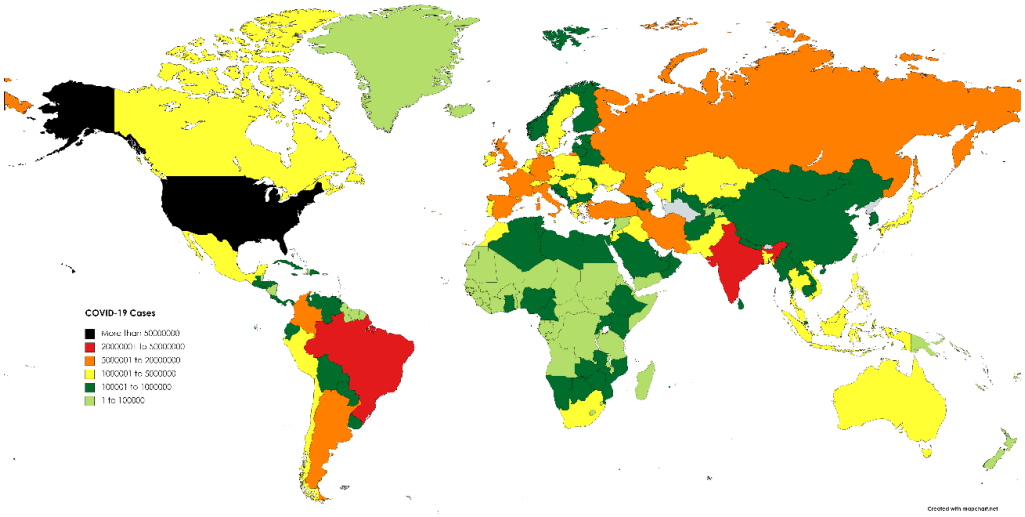


Figure 8 - Reported COVID-19 cases in the world (15/01/2022)

In Figure 9 we can see the distribution of the deaths in the world.

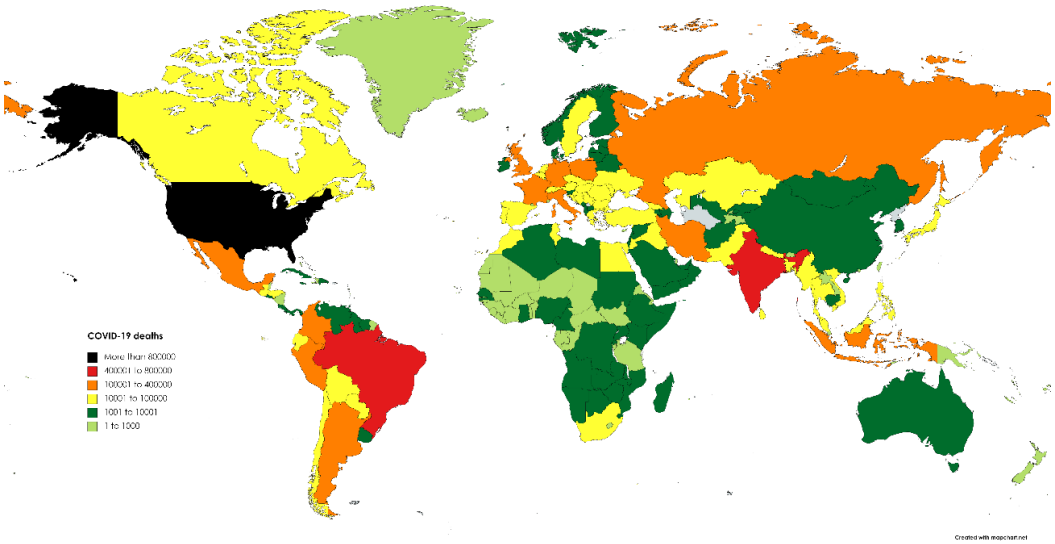


Figure 9 - Reported COVID-19 deaths in the world (15/01/2022)

3.2 Impact in the aviation sector

COVID-19 directly impacted all industries and all sectors of the economy, with a particular focus on aviation, as one of the most affected. Since the first cases of SARS-Cov-2 identified in China at the end of 2019, cases of this same disease have been reported in practically every country in the world, so it is safe to say that it has reached a global scale.

Why is aviation one of the most affected sectors? It is worth remembering that in the initial phase of infection, most countries did not have the means to face the exponential number of serious cases by COVID-19 requiring hospitalization. With healthcare systems

failing, restrictions had to be put in place, such as confinement and border closures. These measures prevented the movement of persons and therefore the quasi-abolition of international tourism, carried out using aviation in 52% [60]. The interdependent relationship between the aeronautical and tourism sectors meant that both were greatly affected, with records of historical losses.

According to [60], when comparing the year 2020 with that of 2019, there is a 50% reduction in seats provided by airlines and a reduction of 60% (-2699 million) of passengers, leading to approximately $371 billion loss of gross passenger operating revenues of airlines. When comparing the estimates for 2021 with 2019, a reduction of 39% to 40% in seats provided by airlines is expected, a reduction of 47% to 49% (-2124 to -2200 million) of passengers, leading to approximate $314 to $324 billion loss of gross passenger operating revenues of airlines.

Comparing both international and domestic passenger traffic in 2020 compared to 2019, there is a 66% reduction in seats made available by airlines for international, against 38% for domestic. There is also a 74% reduction in passengers (-1376 million) for the international against 50% (-1323 million) for the domestic. Also, the approximate losses are of $250 billion in the gross operating revenue of airlines for the international, against $120 billion of loss registered in the domestic.

When comparing the estimates for 2021 with 2019, a reduction of 61 to 63% in seats made available by airlines for the international is expected, against 23 to 24% registered by the domestic. It is also expected a reduction of 72 to 74% of passengers (-1328 to -1367 million) for the international, against 30 to 32% (-796 to -833 million) registered by the domestic, leading to approximate $248 to $255 billion loss of gross passenger operating revenues of airlines against $65 to $69 billion registered by the domestic. For a better understanding of the above values, Figure 10 and Figure 11 are presented.

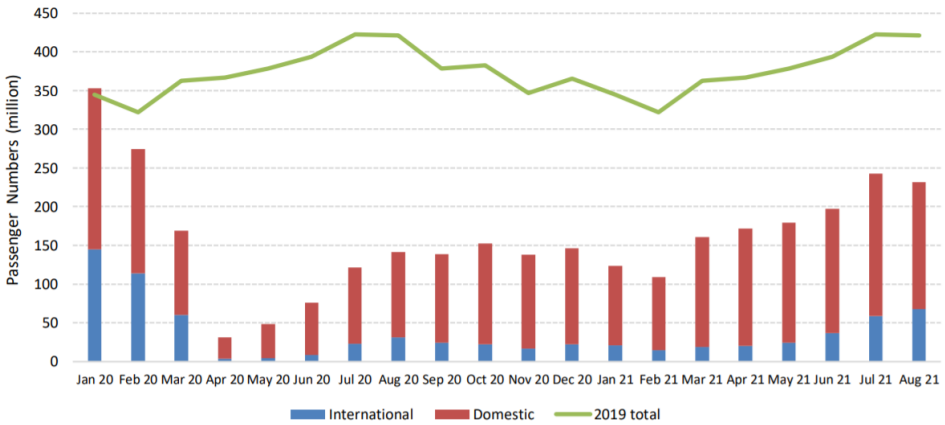


Figure 10 - Monthly passenger numbers in 2020-21 to 2019. Source: adapted form [60].

In Figure 10, we have the number of passengers who traveled by air, both in domestic and international traffic, in the period from January 2020 to August 2021, as well as the total value for the year 2019. After the great reduction in air traffic in the beginning of the pandemic, there is a certain recovery of pre-pandemic values, albeit slowly.

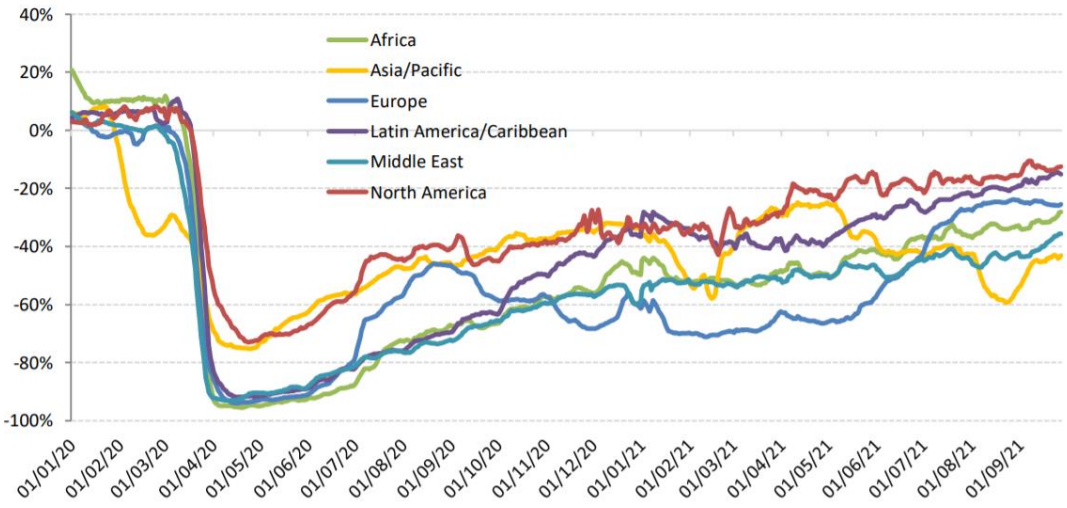


Figure 11 - Comparison of total seat capacity by region. Source: adapted from [60].

In Figure 11, we have a comparison of seats available by airlines according to their region. After the first major crash, there is a certain recovery of pre-pandemic values.

As such, there was an estimated loss of approximately 64,6% of passenger traffic and 66,3% or over $125 billion airport revenues in 2020 compared to business as usual, a 65,9% decline of revenue passenger kilometers (RPKs, both international and domestic) in 2020 compared to 2019. Also a decline in international tourism receipts of $1,3 trillion in 2020, compared to the $1,5 trillion generated in 2019, a fall of global merchandise trade volume by 5,3% in 2020 compared to 2019 and an estimated -3,2% to -3,5% contraction in world GDP in 2020, according to [60].

However, with the decrease in the number of passengers on the planes, there was an acceleration of air cargo transport, thanks to the momentary re-adaptation of some passenger aircraft, which were at a standstill with accumulated losses. This increase in the need to transport cargo is explained by the increase in the number of orders for products online or simply by trying to generate revenue.

In order to boost air traffic and limit the spread of the virus, a serial of measures was put into practice both at airports, by regulatory agencies, and on aircraft, by airlines. According to [61] and [62] the measures implemented were the following:

By the Airports:

- Mandatory temperature controls at the departure airport;
- Drastic reduction of air recirculation by opening windows or using air conditioners with particle retention;
- Respect of the minimum distance of 1.5m between passengers outside the same household;
- Recurrent disinfection of areas (especially handrails, wrists and places susceptible to touch);
- Reorganization of terminals in order to ensure distance between passengers (seats, marks on the floor, barriers);
- Installation of barriers between employees and passengers when it is impossible to ensure a safe distance (check-in, border control);
- Mandatory use of a mask throughout the trip, with the exception of momentary impossibility (eating, drinking, identity check);
- Installation of bottled water vending machines and masks;
- Use of gloves and visor when, for safety reasons, the employee so requires;
- Implementation of properly prepared and disinfected rooms to control passengers with temperatures above the permitted level (specialized medical personnel are required in these rooms);
- Increase in the number of buses for boarding/disembarking an aircraft, due to the imposition of maximum capacity;
- Organization of shifts among staff to avoid crowding;
- Whenever possible online check-in and contactless procedures;
- Accessibility to alcohol-based hand sanitizers for both passengers and employees;
- Restricted access to the terminals for passengers with a boarding pass;
- Restricted access to terminals for passengers with a negative PCR test or digital certificate of vaccination against COVID-19.

By airlines:

- Prior information to passengers of the restrictions and rules to be respected during their trip, via SMS or during online check-in;
- Assured disinfection of the aircraft immediately after disembarkation, with a more thorough cleaning being mandatory at least once a day (at night as a rule);

- Encouragement of passengers to place all hand luggage, without lithium batteries, in the hold in order to prevent the circulation of passengers in the cabin;
- Reservation of a bathroom for the exclusive use of the crew (closest to the cockpit);
- Control of proper use of the mask by passengers;
- Air filtration in the cabin on a recurring basis during the flight, with the recommended HEPA (High Efficiency Particulate Air) filters;
- Control of passenger boarding time on the ground, which cannot exceed thirty minutes without the aid of auxiliary ventilation (Auxiliary Power Unit – APU or Ground Air Conditioning Unit);
- Definition (if possible) of a cabin configuration in which the safe distance between passengers, who do not belong to the same household, is respected;
- Exclusive sale of strictly necessary products, properly packed and sealed, with payment made by card contact;
- Restriction of the non-use of the seatbelt when going to the bathroom in order to limit as much as possible the circulation of passengers in the cabin;
- Maintenance of a stock of masks to supply in case of need;
- Automatic isolation of passengers who have symptoms in their own place, with the right to a dedicated bathroom, with their entire household (even if they do not show symptoms):
    - The crew member who will serve the passenger will be the one closest to the asymptomatic;
    - Should the symptomatic test positive for SARS-Cov-2, all passengers within two rows must be tested and quarantined for 14 days, as well as the entire crew;
    - Should the symptomatic test negative to SARS-Cov-2, the crew returns to work normally;
    - During the testing period, all the above mentioned must remain in isolation;
    - Landing must be done in accordance with the rules of the local authority, and notification of the situation is required before landing.
- Both boarding and landing must be done through the 2 doors and in order of rows;
- Ensure up-to-date contact tracking for all passengers (name, date of birth, address, place of birth, email and phone number).

Clearly, this set of measures will entail a series of costs, both monetary and temporal. If there is a longer time interval between flights, the plane will spend more time on the

ground and the airline will make fewer trips, indirectly leading to both temporal and monetary losses.

Therefore, among the ongoing monetary costs we have:

- Temperature controls (has been identified by EASA as a high-cost but low efficiency measure, because passengers without symptoms, up to 75%, are not detected);
- Greater use of air conditioning with particulate filters;
- Periodic disinfection of terminals, aircraft and baggage (baggage disinfection proved not to be very efficient);
- Alcohol-based hand sanitizers;
- Increase in the number of buses for boarding and disembarking aircraft;
- PCR tests when needed.

Among the momentary monetary costs (which entail significant costs), we have:

- Reconfiguration of terminals (benches, barriers and signalizations);
- Installation of temperature check-points controls (not very efficient as seen before);
- Installation of special particles filters (HEPA filters);
- Installation of barriers between employees and passengers;
- Creation of properly prepared and disinfected rooms to control passengers with temperatures above the permitted level.

In Figure 12, there is the representation of the loss of passenger processing capacity at airports due to the measures implemented to stop COVID-19. There is also the respective detail by sections.

In this way, in red there is the loss of capacity, i.e., very likely that COVID-19 measures reduce capacity with hardly any chance for solving with reasonable time/effort. In yellow there is, the capacity at risk, i.e., a reduction very much depending on layout/process specifics, where solving is generally possible but costly. Finally, in green there is the capacity remaining, either with, “do-nothing” or easy measures sustainable capacity.

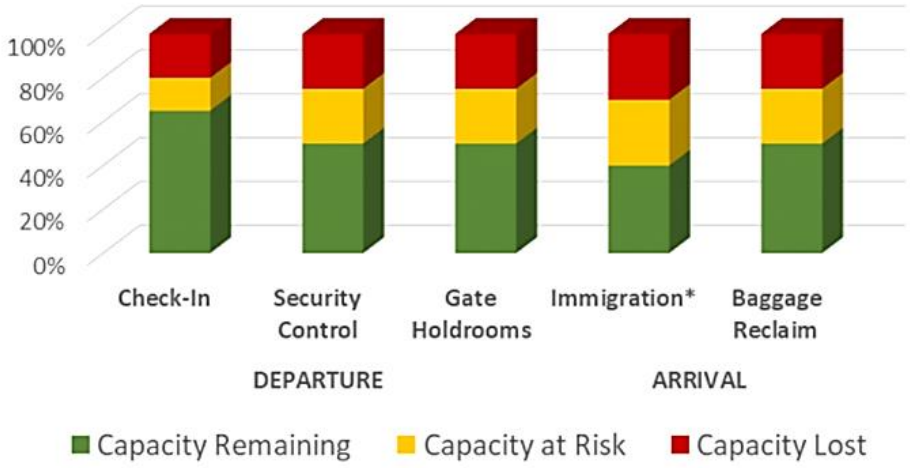


Figure 12 - Capacity lost due to COVID-19 measures. Source: adapted from [63].

After analyzing Figure 12, it is concluded that it is up to airports to find the best relationship between optimizing terminals, in order to increase passenger processing and reduce both waiting times (indirectly with economic impact) and associated costs.

3.3 Interviews

In order to assess the ability of airports to strike the right balance between the cost and effectiveness of the measures implemented to contain the COVID-19 virus, a series of interviews were conducted with experts in the field of air traffic, where nine different entities were contacted (listed below):

- Lisbon, Portugal (Humberto Delgado Airport);
- Barcelona, Spain (Josep Tarradellas Barcelona-El Prat Airport);
- Antwerp, Belgium (Antwerp International Airport);
- São Paulo, Brazil (São Paulo - Guarulhos International Airport);
- Buenos Aires, Argentina (Ezeiza International Airport);
- Melbourne, Australia (Melbourne International Airport);
- North America[1];
- Mexico City, Mexico (Benito Juárez International Airport);
- Medina, Saudi Arabia (Prince Mohammed Bin Abdulaziz International Airport);

Since COVID-19 is now part of the global reality, it was important to contact airports on several continents to check the possibility of different measures being implemented

[1] No specific airport was addressed due to the fact that the specialist works with a large number of airports in the area and not only with one of them.

depending on the regulatory bodies, cultures and ways of acting in each place. Therefore, and for the reasons listed, the following countries were chosen:

- Portugal, being the origin country of the dissertation author;
- Spain, due to its geographical proximity to where the dissertation is being written. The aim is to verify the homogeneity of the measures implemented in the Iberian Peninsula;
- Belgium, in order to verify whether or not there is a standardization of the measures implemented in Europe;
- Brazil and Argentina, since both belong to another part of the world (South America) and by their geographical proximity, being important to know whether or not identical measures have been implemented (similar to what was done in Europe)
- Australia, due to its geographical location and the fact that it is a another continent.
- North America due to its global relevance, with the USA being a reference, even influencing other countries or areas of the globe;
- Mexico, due its location in Central America. As it is located between other case studies such as Brazil or USA, the aim is to determine the similarities and differences between the measures implemented in the country and the rest of the continent;
- Finally, Saudi Arabia because it was the epicenter of the MERS crises. The aim is to verify if lessons were learned from the previous crises and also to cover all continents.

Once the entities to be contacted had been chosen in accordance with the stipulated criteria, dialogue began with the people indicated by Professor Jorge Miguel dos Reis Silva, who, in turn, referred specialists capable of answering the questions posed below, through an email-interview. In this email, there was an introduction about the identity and occupation of the author of the dissertation, a short contextualization followed by pertinent questions put to the experts, in order to identify which measures were implemented to stop COVID-19, their mode of implementation and their efficiency. Below follows the body of the email:

I am a master's student in aeronautical engineering at the University of Beira Interior, currently doing my dissertation with the advisor Professor Jorge Miguel dos Reis Silva. My dissertation covers topics such as emergency plans, COVID-19 and measures implemented at airports to stop the spread of the virus. As part of the dissertation and

by answering a few questions, I would like to ask you about procedures put in place during the pandemic crisis at the airport where you are working.

Here are the questions I would like to address:

1.Does the airport where you work have an emergency plan or something similar in place?

2. Did the airport emergency plan include measures and procedures to control infectious and easily transmitted diseases?

2.1. If so, were they implemented exactly according to the emergency plan or were adjustments needed? Have any gaps been detected in the emergency plan?

2.2. If not, how the airport responded to COVID-19? Has it ceased its activity temporarily or has it implemented emergency measures?

3. Were these measures maintained from day one (the beginning of the pandemic situation) to the present day, or were adjustments made as the pandemic unfolded?

4. If adjustments were made, why were they necessary?

5. Who decided on the measures to be implemented at the airport? Management or regulatory organizations such as ICAO and EASA?

6. What measures have been implemented?

7. Have these measures been effective in detecting patients infected with SARS-CoV-2? I.e., how much has the probability of SARS-CoV-2 positive passengers traveling through the airport decreased?

8. Have these measures proven to be cost effective? Was any of the measures abandoned after proving to be unprofitable? If so, what was it?

9. Do you believe these were the best possible steps to take, so to stop COVID-19 or is there scope for improvement?

10. If you believe that other measures should have been implemented, what would they be?

11. What was the total cost of the measures put in place to stop the spread of the virus?

12. To what extent has the airport been affected economically during this pandemic crisis and what was the loss recorded during this period, since the beginning of the pandemic until the present moment?

13. At the operational level, what was the associated cost, i.e. what was the traffic reduction at the airport? Has your airport returned to pre-pandemic values in recent months?

14. If not, when do you think your airport will return to these values?

Unfortunately, it was not possible to obtain answers from all the airports the author wanted, therefore the answers collected are indicated below.

3.3.1 Portugal (Humberto Delgado Airport)

1. Lisbon airport has emergency and contingency plans. The COVID 19 pandemic crisis falls under IROPS (Irregular Operations) which, in turn, falls under contingency plans.

2. Given the lack of occurrences in the past, contingency plans did not cover any pandemic situation, thus it was necessary to create procedures to deal with this health crisis. Currently, this contingency plan already exists and is dynamic, allowing for action to be taken according to the degree of disruption.

> 2.2. Initially, the airport ceased its activities and only humanitarian, repatriation and cargo flights were operated.

3. As the pandemic evolved, new guidelines emerged and the contingency plan was adapted to the reality of the moment.

4. This was due to the lack of historical context in being able to deal with such disruption as the current health crisis.

5. In designing IROPS plans, government guidelines have to be considered, so that procedures are in accordance with what has been previously decreed

6. Social distancing, compulsory wearing of masks, use of new technologies and use of biometric technology.

Recently a system of wristbands was introduced, whereby a passenger travelling within national territory has a green wristband with which there is no obligation to perform a PCR test, a passenger coming from abroad has a blue wristband which is controlled by

the SEF (Foreigners and Borders Service) and the remaining passengers must present a negative PCR test and be controlled.

7. These measures were effective in detecting infected passengers, reducing the likelihood of COVID-19 positive passengers entering Portuguese territory.

8. When any new disruption occurs, measures are projected and idealised which when transported to reality may be not very efficient. In such cases, an analysis has to be made in order to solve the problem and improve the efficiency of the operation. To that effect, there have been measures in the past that had to be readjusted.

9. The airport has to adapt to government guidelines. Therefore, the measures implemented were those that, as far as possible, complied with what was stipulated.

10. In the interviewee's opinion, there was good cooperation in dealing with this health crisis.

11. for confidentiality reasons this figure could not be disclosed.

12. Airports were greatly affected, and due to the lack of experiences prior to the pandemic, it was difficult to predict the extent of the disruption, given that the aviation sector was one of the most affected sectors, especially in the first months of the pandemic.

13. In the first phase, at the time of containment, the number of movements was reduced from 700 to 30. This drastic reduction in movements caused logistical problems in terms of aircraft parking. Aviation recovered somewhat in the summer of 2021, however, as the pandemic progressed, a new reduction in air traffic was observed in January 2021. There is a fear on the part of passengers to fly.

14. Air traffic is expected to recover by 2024.

3.3.2 Argentina (Ezeiza International Airport)

1. Yes, the existence of an emergency plan it is a regulatory requirement, all airports have one. And the responsible to elaborate, update, supervise and execute the plan is the aeronautical authority that in Argentina is the “Administración Nacional de Aviación Civil (ANAC)”.

2. The health emergency is contemplated in the plan. It is one of the sections. The transmission of diseases that may come from abroad and enter by air transportation that entail massive contact was already contemplated in the emergency plan.

2.1. Actually, there have been changes. Even though the health emergency was already stipulated in the plan, once it was put into practice, it was concluded that what was contemplated was not deep enough to face the pandemic. In this way, the pre-stipulated measures were not enough to face the health crisis that was experienced.

3. In fact, the measures have changed greatly over time, either because of the pandemic's progress (increase or decrease of cases) or because of a better insight into the efficiency of some measures.

4. For instance, vaccination certificates were not requested at the beginning of the pandemic because there were no vaccines yet, something that changed with time. Now is a requirement to travel by plane almost everywhere.

5. Many organizations were involved in the implementation of the measures. In addition to ANAC, other state agencies linked to health and emigration also played their part in mitigation. Thus, ANAC has drafted documents presenting a series of protocols and particular procedures to be applied at the airport. Thus, the airport was directly responsible for the entire process up until the detection of a possible positive case, after which it was the responsibility of the health authorities to follow up on the situation.

6. The measures implemented were divided in three sections:

- At the airport: Mandatory use of mask, all the documents required (negative PCR test, vaccination certificate, COVID-19 tracking form, medical insurance, etc.), earlier check-in, only passengers with flights departing from the terminal and the companions of passengers with a disability (when required) will be granted access and temperature checking points.
- Check-in: Check in online for those flights in which this option is available, minimum physical distancing indicated by the signs, check-in staff will only ask documentation if necessary.
- Boarding: Minimum physical distancing indicated by personnel and information signs, scanners for boarding pass scanning (no physical contact), orderly boarding and physical distancing, passengers travelling in Business class or Premium Economy class will be the last to board, buses sanitized and disinfected on a regular basis and VIP lounges closed until April 2021.

Regarding testing, like most countries, prior to entry you had to have a negative PCR performed within 72 hours prior to boarding. This verification was done by the airline

company at the time of check-in. Upon arrival, this test was presented to the immigration authorities along with your passport and travel documentation. Then, on departure from the airport, an antigen test was done and had to be negative. Finally, after seven days the passenger would have to take a new PCR test.

7. This question is difficult to answer because the positivity rate of the PCR test done seven days after arrival is state data. But the positivity rate on the antigen test upon arrival was less than 1%. It ranged from 0, 5% to 0, 8%. Hence, negative PCR on boarding was thought to be a very efficient measure in detecting COVID-19 positive cases.

8. It depends on the measures, some of them were cost/efficient but others don't. The clearest case was the temperature check points control. This measure from a technical point of view was not very effective in detecting positive COVID-19 cases. Nevertheless, it was implemented with the intention to be a placebo method, in order to create a sensation of care for those how enter the airport. With the time this measure was abolish and changed for other ones. Other of the measures abolish was one implemented at Ezeiza. There was implemented, at Ezeiza, a 2h gap between the arrival of two international flights. This meant that only one of twenty-seven gates was open and for a really short periods of time. With the time, this measure was abolished due to the enormous economic impact.

9. In the opinion of the interviewd, the 2h gap between flights was the worst measure implemented, being too excessive. The interval between landings could have been shortened, allowing more passengers and a better use of the airport's resources.

10. Again about the 2h gap between flights, the same results could have been achieved with more open gates or with shorter time frames. All that was needed to improve logistics.

12. "Ministro Pistarini Ezeiza" International Airport, showed a reduction of $835, 1407 (-70.7%), in gross profits from passenger traffic in 2020 compared to the contiguous period in 2019.

13. In terms of incoming and outgoing passengers, a reduction of 53489 (-62.5%) was detected, of the total recorded in 2020, compared to that recorded in 2019.

14. Air traffic is projected to recover fully by 2025.

3.3.3 North America

As far as North America is concerned, no specific airport was addressed due to the fact that the specialist works with a large number of airports in the area and not only with one of them.

1. Yes, they all have emergency plans.

2. Yes, a lot of the airports had already some measures to be implemented in case of an infectious disease but in North America, the airports, rely a lot on the government. In the United States of America, for instance, very often they let the state government decide the level of risk and the measures that should be implemented in the airport. There were different states of emergency depending on the state, so there were also different measures being implemented across the country. However, some measures were decided by the federal government and in that case all states needed to implement those.

3. There were changes made over time and also according to the state of emergency present in each state at that time. Not all states were hit at the same time by the pandemic. Now, in Canada all airports had the same measures because they are all federal regulated which is not the case in the USA where airports are state regulated. But depending in the state of emergency in Canada also measures have been changed with time. Meaning that the measures were volatile with the pandemic.

4. They were necessary because the pandemic situation is always changing and evolving.

5. In Canada it was the government that decided the measures implemented at any time in all airports, but in the USA, the airports had more control about it, however some of them where imposed by either the state, the county or by the federal government.

7. In North America the airports were in the back ground and let health authorities and airlines responsible for detecting COVID-19 cases (main issue detected by the locator and his team). For instance, controlling if passengers are wearing masks, if they are vaccinated or have all the passenger information in order was not under the responsibility of the airports. Also, if the airline has a potential positive should inform the airport to clean the area or, in some cases, the airport had a little room to put the person in isolation, but not more than that. Contrary to Europe or Asia, where airports very often had clinics or medical staff to examine the patient.

8. A lot of measures have proven not being cost effective, they were just too expensive and didn´t really add more safety. A bit like what happened after September the 11th, a

lot of the measures remained until nowadays but some of them were abandoned after some time. Some of the measures were just a bit over the top and not really effective. The most known case where the infra-red cameras, that were vastly used in Europe more specifically in Italy but after 3/4 months were abandoned because they didn´t really told a lot, i.e., not very effective. In North America some of the airports used that technology but they reached the same conclusion as Europe about this equipment. Social distancing and controlling the flow of the passengers in order to avoid big crowds is far more efficient. Spring disinfect showers and UV raised machines that would disinfect luggage were also some abandoned measures due to the lack of cost/efficiency.

3.3.4 Mexico (Benito Juárez International Airport)

For Mexico, the expert made available a document [64] where it was possible to gather the information bellow.

1. Yes, there is an emergency plan at Benito Juárez International Airport.

2. In 2009, following the swine flu (H1N1) the airport management in coordination with the government developed a plan with measures to implement in case of emergency. Of all the emergencies addressed, illness / sudden death was one of them.

> 2.1. Some modifications were made throughout the pandemic, due to the evolution of the pandemic or because other technologies proved to be more efficient.

3. Some changes have been made during the pandemic and as greater clarity is achieved in terms of additional measures, such as effective COVID-19 testing and immunity, further measures can be incorporated into passenger processing to further mitigate risks and increase confidence in air travel, leading further towards the resumption of "normal" operations.

4. Because the overall pandemic situation in Mexico, like other countries in the world, is always changing so adjustments needed to be made. Also a development of some technologies have been made in the last months.

5. In order to reduce the risk of Covid-19 coronavirus infection and protect the health of passengers, users and workers, the Benito Juárez International Airport, in coordination with airlines and authorities, applies the sanitary protocols recommended by the Ministry of Health of Mexico.

6. According to the airport area different measures were implemented being the following:

- Exit terminal: temperature check points, social distancing, use of personal protective equipment, cleaning and disinfection, COVID-19 testing and immunity passports.
- During the flight: High efficiency air filters (HEPA), limited movement in the cabin, use of masks, packaged comestibles and comprehensive guidelines for cabin crew including the management of a suspected case of communicable disease on board.
- Arrival at airport: customs control, baggage collection and verifications of passengers in transit.

Among the most widely used and/or innovative technologies are: electrostatic sprayers, ultraviolet light and robots for booth disinfection, high efficiency air filters and new seat designs for aircrafts.

7. The concept of layered mitigation measures has been successful in significantly reducing the risks of contagion in air transport. Technology, innovation and automation will be the key elements in the recovery of the global airline industry.

12. In May 2020, CANAERO estimated a loss of US$5,3 billion for Mexico's airline industry as a result of the COVID-19 pandemic. The organization also estimated that 534,000 jobs are at risk, since for every job lost in the airline industry. For every job that is lost in the airline industry, twenty-eight additional jobs are lost in the value chains associated with this industry.

13. In general, passenger flows were more deeply affected (-52.8 percent year-over-year) and a lesser impact on cargo (-11.7 percent year-over-year). In other words, there was a differentiated impact. In addition, domestic flows were less affected than international flows, meaning that the recovery in both passenger and cargo has been quicker.

14. The recovery of domestic passenger flows is expected to occur in the first half of 2021 and international passenger flows, in the best case scenario, until the last four months of 2021. In the case of air cargo, domestic flows recovered since September 2020 and foreign trade flows since October 2020; this is a good sign for this component of air activity in Mexico.

3.3.5 Saudi Arabia (Prince Mohammed Bin Abdulaziz Airport)

In the case of the international airport "Prince Mohammed Bin Abdulaziz", it was not possible to obtain answers from experts, however, through [65] and [66] it was possible to obtain the answers mentioned below.

1. Prince Mohammed Bin Abdulaziz International Airport has an Airfield Emergency Response Plan.

2. The Aerodrome Emergency Response Plan includes section 6.2 called Public Health Emergency Preparedness Plan which includes the measures to be implemented in the event of an infectious disease.

    2.1. Although there was a section on infectious diseases, the plan was not prepared to deal with a pandemic situation for months.

3. Like other airports, the response to COVID-19 has slightly changed over time.

4. New technologies and changes in the global pandemic situation were the reasons why changes were made.

5. The response plan was established in coordination between agencies such as the General Civil Aviation Authority (GACA), Tibah, Ground Service Companies, Ministry of Interior, Saudi Customs and Immigration Department and for a coordinated preparation and response to a Public Health Emergency (PHE).

6. Social distancing (1.5m), mandatory use of masks, regular disinfection of areas, encouraging passengers to clean their hands with soap and water, temperature checkpoints through security and on arrival, only passengers and airport staff are allowed inside the terminal, contactless payment, instructions and signage to ensure a safe physical distance with others, baggage carriers and trolleys are disinfected frequently [66].

3.4 Surveys

After the interviews with the experts, a small survey was conducted, this time among the general public, where the 'sine qua non' condition for participating in the questionnaire was to have travelled by air in 2021. The questionnaire would be automatically submitted in case the individual had not travelled in 2021. This survey was prepared using Google

Forms and distributed online. In total, 300 responses were recorded, of which only 186 were valid for having flown in 2021. The set of questions is as follows:

1. Have you recently traveled by plane (since January 2021)?

- Yes
- No

2. What was the main airline that you flight with?

3. What was the departure airport?

4. What was the airport of arrival?

5. Where did you stop? If applicable, insert all airports where you stopped.

6. Were you previously informed about the measures and procedures in the airport by the airline?

- Yes
- No

7. Did you fill out a COVID-19 tracking form?

- Yes
- No

8. Did you check in online?

- Yes
- No

9. During check-in, did you notice any physical barriers between you and the airport/airline staff?

- Yes
- No
- Not applicable

10. Did you notice any readjustment of the terminal to ensure social distance?

- Yes

- No

11. If yes, where did you see these changes? As many answers as necessary.

- At the airport entrance
- In the check-in area
- In the security control area
- At the departure terminal
- In the duty-free zone
- In the boarding area
- On the plane
- In the landing area
- In the baggage claim area
- At the arrival terminal
- At the airport exit

12. Did you notice more cleaning and disinfection than usual? That is, handrails, doors, benches and other cleaner areas?

- Yes
- No
- Yes, but there is a lot of room for improvement

13. Is the use of a mask mandatory during the entire trip? That is, from the departure terminal to the arrival terminal?

- Yes
- No
- Only in some cases

14. Was your temperature been measured?

- Yes
- No

15. If so, where? As many answers as necessary.

- At the airport entrance
- In the check-in area
- In the security control area

- At the departure terminal
- In the duty-free zone
- In the boarding area
- On the plane
- In the landing area
- In the baggage claim area
- At the arrival terminal
- At the airport exit

16. Have you shown fever?

- Yes
- No

16.1. Were you sent to a disinfected room?

- Yes
- No

16.2. In that room, were any health professionals present?

- Yes
- No

16.3. Describe a little about your experience, what you saw, what you felt and the process itself.

Note: If the answer to 16. is “Yes” then and only then 16.1., 16.2. and 16.3. would be questioned.

17. Did you notice new contactless procedures?

- Yes
- No

18. If yes, can you specify?

19. Have you seen water and masks vending machines?

- Only water
- Only masks

- Both
- None

20. Were there alcohol-based solutions available?

- Yes, a lot of them
- Yes, a few of them
- No

21. Have you been encouraged to put your carry-on baggage in the airline's hold?

- Yes
- No

22. Has your luggage been disinfected?

- Yes
- No
- I don’t know

23. Have you been asked for a vaccination certificate or a negative PCR test?

- Yes
- No

24. Did you board in queue order?

- Yes
- No

25. Did you land in the queue order?

- Yes
- No

26. Was, in the plane, a dedicated crew bathroom?

- Yes
- No
- I don’t know

27. During your trip, were there anyone with symptoms of COVID-19?

- Yes
- No

27.1. Has the person in question been isolated?

- Yes
- No
- I don´t know

27.2. Was the symptomatic person's family also isolated?

- Yes
- No
- I don’t know

27.3. Has any crew member been assigned to service the symptomatic and his family?

- Yes
- No
- I don’t know

27.4. Did you notice anything distinct in the landing?

- Yes
- No

27.5. If yes, could you elaborate further?

Note: If the answer to 27. is “Yes” then and only then 27.1., 27.2., 27.3., 27.4. and 27.5. would be questioned.

28. How much time did you waste on each stage of your journey beyond the usual?

28.1. At the airport entrance:

- Nothing to note
- 5 to 10 minutes
- 10 to 15 minutes

- 15 to 30 minutes
- 30 to 60 minutes
- 60 to 120 minutes
- More than 120 minutes

28.2. In the check-in area:

- Nothing to note
- 5 to 10 minutes
- 10 to 15 minutes
- 15 to 30 minutes
- 30 to 60 minutes
- 60 to 120 minutes
- More than 120 minutes

28.3. In the security control area:

- Nothing to note
- 5 to 10 minutes
- 10 to 15 minutes
- 15 to 30 minutes
- 30 to 60 minutes
- 60 to 120 minutes
- More than 120 minutes

28.4. At the departure terminal:

- Nothing to note
- 5 to 10 minutes
- 10 to 15 minutes
- 15 to 30 minutes
- 30 to 60 minutes
- 60 to 120 minutes
- More than 120 minutes

28.5. In the duty-free zone:

- Nothing to note
- 5 to 10 minutes

- 10 to 15 minutes
- 15 to 30 minutes
- 30 to 60 minutes
- 60 to 120 minutes
- More than 120 minutes

28.6. In the boarding area:

- Nothing to note
- 5 to 10 minutes
- 10 to 15 minutes
- 15 to 30 minutes
- 30 to 60 minutes
- 60 to 120 minutes
- More than 120 minutes

28.7. On the plane:

- Nothing to note
- 5 to 10 minutes
- 10 to 15 minutes
- 15 to 30 minutes
- 30 to 60 minutes
- 60 to 120 minutes
- More than 120 minutes

28.8. In the landing area:

- Nothing to note
- 5 to 10 minutes
- 10 to 15 minutes
- 15 to 30 minutes
- 30 to 60 minutes
- 60 to 120 minutes
- More than 120 minutes

28.9. In the baggage claim area:

- Nothing to note
- 5 to 10 minutes
- 10 to 15 minutes
- 15 to 30 minutes
- 30 to 60 minutes
- 60 to 120 minutes
- More than 120 minutes

28.10. At the arrival terminal:

- Nothing to note
- 5 to 10 minutes
- 10 to 15 minutes
- 15 to 30 minutes
- 30 to 60 minutes
- 60 to 120 minutes
- More than 120 minutes

28.11. At the airport exit:

- Nothing to note
- 5 to 10 minutes
- 10 to 15 minutes
- 15 to 30 minutes
- 30 to 60 minutes
- 60 to 120 minutes
- More than 120 minutes

After sifting through the questions that make up the questionnaire, here are the results. For a better understanding, we have chosen to represent the results graphically, using percentages. Thus, we have:

1. Have you recently traveled by plane (since January 2021)?

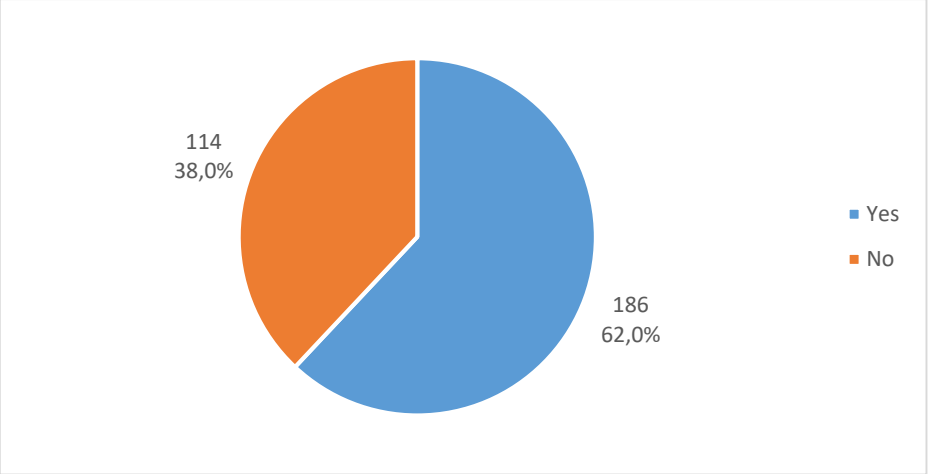


Figure 13 - Results to question 1 of the inquiry.

2. What was the main airline that you flight with?

Table 4 - Results to question 2 of the inquiry.

Airline Name	Number of occurrences
Ryanair	46
TAP Air Portugal	22
EasyJet	17
Lufthansa	13
Air France	10
KLM	9
SATA Azores Airlines	8
LATAM	4
Air Europa	3
Croatia Airlines	3
Emirates Airline	3
Iberia	3
Swiss Air	3
Turkish Airlines	3
Vueling Airlines	3
Wizz Air	3
Aegean Airlines	2
Air Canada	2
Air Malta	2
Finnair	2
Qatar Airways	2
SAS Airlines	2
Transavia	2
United Airlines	2
Aerolineas Argentina	1
Air Serbia	1
American Airlines	1

Avianca	1
Azul Linhas Aereas	1
British Airways	1
Brussels Airlines	1
Delta	1
EuroAtlantic Airways	1
GOL	1
LOT Polish Airlines	1
Singapore Airlines	1
Tarom	1
TUI Airlines	1
Tunisair	1
Virgin Australia	1
VOLOTEA	1

3. What was the departure airport?

Table 5 - Results to question 3 of the inquiry.

Airport name	Number of occurrences
Francisco Sá Carneiro Airport (OPO/LPPR)	49
Lisbon Humberto Delgado Airport (LIS/LPPT)	31
Paris Roissy Charles de Gaulle (CDG/LFPG)	10
Madrid Barajas Airport (MAD/LEMD)	7
Bordeaux-Mérignac Airport (BOD/LFBD)	6
Amsterdam Airport - Schiphol (AMS/EHAM)	5
São Paulo Guarulhos International Airport (GRU/SBGR)	5
Helsinki Vantaa Airport (HEL/EFHK)	4
João Paulo II Airport (PDL/LPPD)	4
Frankfurt Airport (FRA/EDDF)	3
Funchal Cristiano Ronaldo Airport (FNC/LPMA)	3
Milan Bergamo Airport (BGY/LIME)	3
Washington Dulles International Airport (IAD/KIAD)	3
Belgrade Nikola Tesla Airport (BEG/LYBE)	2
Brussels Airport (BRU/EBBR)	2
Heathrow Airport (LHR/EGLL)	2
Lajes International Airport (TER/LPLA)	2
London City Airport (LCY/EGLC)	2
Lyon-Saint-Exupéry Airport (LYS/LFLL)	2
Rio de Janeiro - Santos Dumont General Airport (GIG/SBRJ)	2
Sofia Airport (SOF/LBSF)	2
Split Airport (SPU/LDSP)	2
Warsaw Chopin Airport (WAW/EPMO)	2
Bâle Mulhouse Fribourg Airport (BLS/LFSB)	1
Bari Karol Wojtyla Airport (BRI/LIBD)	1
Berlin Brandenburg Airport (BER/EDDB)	1
Bogota El Dorado International Airport (BOG/SKBO)	1

Brussels South Charleroi Airport (CRL/EBCI)	1
Bucharest Henri Coanda International Airport (OTP/LROP)	1
Buenos Aires Jorge Newbery Airport (AEP/SABE)	1
Calgary International Airport (YYC/CYYC)	1
Dubrovnik Airport (DBV/LDDU)	1
Dusseldorf International Airport (DUS/EDDL)	1
Eindhoven Airport (EIN/EHEH)	1
Enschede Twenthe Airport (ENS/EHTW)	1
Faro Airport (FAO/LPFR)	1
Franz Josef Strauss International Airport (MUC/EDDM)	1
Goiania Santa Genoveva Airport (GYN/SBGO)	1
Göteborg Landvetter Airport (GOT/ESGG)	1
Larnaca International Airport (LCA/LCLK)	1
Luqa Malta International Airport (MLA/LMML)	1
Manchester Airport (MAN/EGCC)	1
Marseille Provence Airport (MRS/LFML)	1
Melboune Airport (MEL/YMML)	1
Rotterdam The Hauge Airport (RTM/EHRD)	1
Stockholm Arlanda Airport (ARN/ESSA)	1
Toulouse Blagnac Airport (TLS/LFBO)	1
Valencia International Airport (VLC/LEVC)	1
Wroclaw Copernicus Airport (WRO/EPWR)	1
Zagreb Franjo Tudman Airport (ZAG/LDZA)	1
Beauvais-Tillé Airport (BVA/LFOB)	1
Rome Fiumicino Airport (FCO/LIRF)	1
Hamburg Airport (HAM/EDDH)	1
Paris Orly Airport (ORY/LFPO)	1
Suvarnabhumi Airport (BKK/VTBS)	1
Milan Malpensa Airport (MXP/LIMC)	1

4. What was the airport of arrival?

Table 6 - Results to question 4 of the inquiry.

Airport name	Number of occurrences
Lisbon Humberto Delgado Airport (LIS/LPPT)	16
Francisco Sá Carneiro Airport (OPO/LPPR)	11
Brussels Schipol Airport (BRU/EBBR)	8
João Paulo II Airport (PDL/LPPD)	8
Funchal Cristiano Ronaldo Airport (FNC/LPMA)	6
Paris Orly Airport (ORY/LFPO)	5
Frankfurt Airport (FRA/EDDF)	4
Heathrow Airport (LHR/EGLL)	4
Madrid Barajas Airport (MAD/LEMD)	4
Nice Côte d'Azur Airport (NCE/LFMM)	4
Paris Roissy Charles de Gaulle (CDG/LFPG)	4
Athenes Elefthrios Venizelos (ATH/LGAV)	3

Barcelona El Prat Airport (BCN/LEBL)	3
Copenhagen Airport (CPH/EKCH)	3
Dubai International Airport (DXB/OMDB)	3
Galileo Galilei Airport (PSA/LIRP)	3
Luqa Malta International Airport (MLA/LMML)	3
Tenerife South Airport (TFS/GCTS)	3
Vienna International Airport (VIE/LOWW)	3
Zurich Airport (ZRH/LSZH)	3
Belem Val de Cans Airport (BEL/SBBE)	2
Dublin Airport (DUB/EIDW)	2
Eindhoven Airport (EIN/EHEH)	2
Geneva International Airport (GVA/LSGG)	2
Helsinki Vantaa Airport (HEL/EFHK)	2
Istambul Airport (IST/LTFM)	2
Johannesburg International Airport (JNB/FAOR)	2
Lyon-Saint-Exupéry Airport (LYS/LFLL)	2
Malaga Costa Del Sol Airport (AGL/LEMG)	2
Male Velana international Airport (MLE/VRMM)	2
Palma de Mallorca Airport (PMI/LEPA)	2
Valencia International Airport (VLC/LEVC)	2
Venice Marco Polo Airport (VCE/LIPZ)	2
Amsterdam Airport - Schiphol (AMS/EHAM)	1
Antalya Airport (AYT/LTAI)	1
Bâle Mulhouse Fribourg Airport (BLS/LFSB)	1
Beauvais-Tillé Airport (BVA/LFOB)	1
Berlin Brandenburg Airport (BER/EDDB)	1
Bilbao Airport (BIO/LEBB)	1
Birmingham-Shuttlesworth International Airport (BHX/EGBB)	1
Bogota El Dorado International Airport (BOG/SKBO)	1
Bologna Guglielmo Marconi Airport (BLQ/LIPE)	1
Bordeaux-Mérignac Airport (BOD/LFBD)	1
Bremen Airport (BRE/EDDW)	1
Brussels South Charleroi Airport (CRL/EBCI)	1
Canberra Airport Australia (CBR/YSCB)	1
Cancun International Airport (CUN/MMUN)	1
Curitiba Afonso Pena Airport (CWB/SBCT)	1
Faro Airport (FAO/LPFR)	1
Flores Airport (FLW/LPFL)	1
Franz Josef Strauss International Airport (MUC/EDDM)	1
Glasgow Prestwick Airport (GLA/EGPF)	1
Graz Airport (GRZ/LOWG)	1
Heraklion Airport (HER/LGIR)	1
Indira Gandhi International Airport (DEL/VIDP)	1
Jerez Airport (XRY/LEJR)	1
Kefalonia Cephalonia International Airport (EFL/LGKF)	1
Kiruna Airport (KRN/ESNQ)	1

Kokkola-Pietarsaari Airport (KOK/EFKK)	1
Lajes International Airport (TER/LPLA)	1
Ljubljana Airport (LJU/LJLJ)	1
London Luton Airport (LTN/EGGW)	1
Maceio Zumbi dos Palmares International Airport (MCZ/SBMO)	1
Mahon Menorca Airport (MAH/LEMH)	1
Marseille Provence Airport (MRS/LFML)	1
Miami International Airport (MIA/KMIA)	1
Monastir-Habib Bourguiba International Airport (MIR/DTMB)	1
Nairobi Jomo Kenyatta International Airport (NBO/HKJK)	1
Naples Airport (NAP/LIRN)	1
Oslo Gardermoen Airport (OSL/ENGM)	1
Phuket International Airport (HKT/VTSP)	1
Porto Santo Airport (PXO/LPPS)	1
Princess Juliana International Airport (SXM/TNCM)	1
Pula Airport (PUY/LDPL)	1
Punta Cana International Airport (PUJ/MDPC)	1
Riga International Airport (RIX/EVRA)	1
Rome Fiumicino Airport (FCO/LIRF)	1
Salt Lake City International Airport (SLC/KSLC)	1
San Andres International Airport (ADZ/SKSP)	1
São Paulo Congonhas Airport (CGH/SBSP)	1
São Paulo Guarulhos International Airport (GRU/SBGR)	1
Singapore Changi Airport (SIN/WSSS)	1
Skiathos Island National Airport (JSI/LGSK)	1
Suvarnabhumi Airport (BKK/VTBS)	1
Tangier-Ibn Battouta Airport (TNG/GMTT)	1
Teniente Luis Candelaria International Airport (BRC/SAZS)	1
Toulouse Blagnac Airport (TLS/LFBO)	1
Vancouver International Airport (YVR/CYVR)	1
Victoria International Airport (YYJ/CYYJ)	1
Vilnius International Airport (VNO/EYVI)	1
Willemstad Curacao Hato Airport (CUR/TNCC)	1
Wroclaw Copernicus Airport (WRO/EPWR)	1

5. Where did you stop? If applicable, insert all airports where you stopped.

Table 7 - Results to question 5 of the inquiry.

Airport name	Number of occurrences
Frankfurt Airport (FRA/EDDF)	5
II Caravaggio International Airport (BGY/LIME)	3
Amsterdam Airport - Schiphol (AMS/EHAM)	2
Franz Josef Strauss International Airport (MUC/EDDM)	2
Istambul Airport (IST/LTFM)	2
Bologna Guglielmo Marconi Airport (BLQ/LIPE)	1
Helsinki Vantaa Airport (HEL/EFHK)	1
João Paulo II Airport (PDL/LPPD)	1

Paris Orly Airport (ORY/LFPO)	1
Paris Roissy Charles de Gaulle (CDG/LFPG)	1
São Paulo Guarulhos International Airport (GRU/SBGR)	1
Zurich Airport (ZRH/LSZH)	1
London Stansted Airport (STN/EGSS)	1
Fortaleza Airport (FOR/SBFZ)	1
Brasília International Airport (BSB/SBBR)	1
Viracopos International Airport (VCP/SBKP)	1
Rio de Janeiro - Santos Dumont General Airport (GIG/SBRJ)	1
Salvador International Airport (SSA/SBSV)	1
Recife/Guararapes - Gilberto Freyre Airport (REC/SBRF)	1
San Francisco International Airport (SFO/KSFO)	1
Hamad International Airport (DOH/OTHH)	1

6. Were you previously informed about the measures and procedures in the airport by the airline?

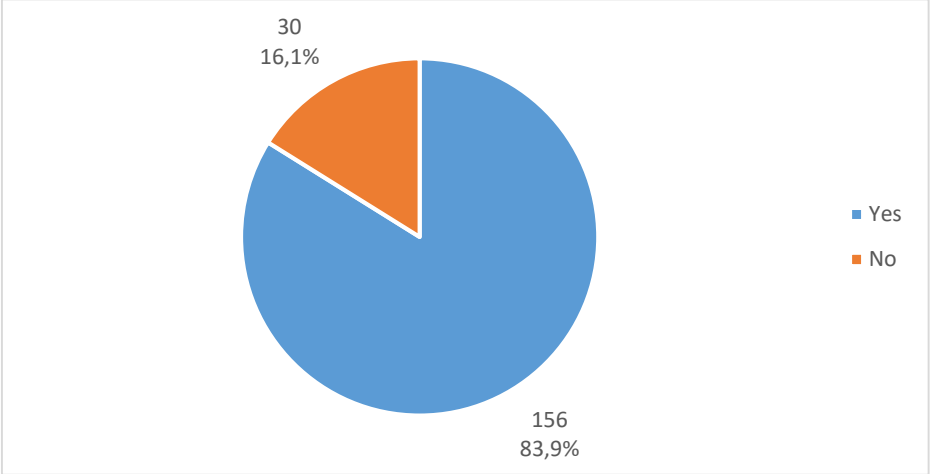


Figure 14 - Results to question 6 of the inquiry.

7. Did you fill out a COVID-19 tracking form?

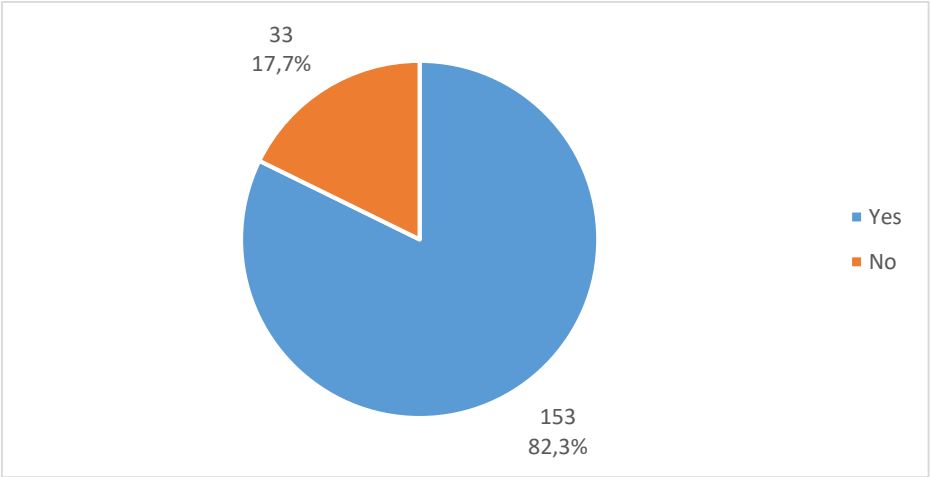


Figure 15 - Results to question 7 of the inquiry.

8. Did you check in online?

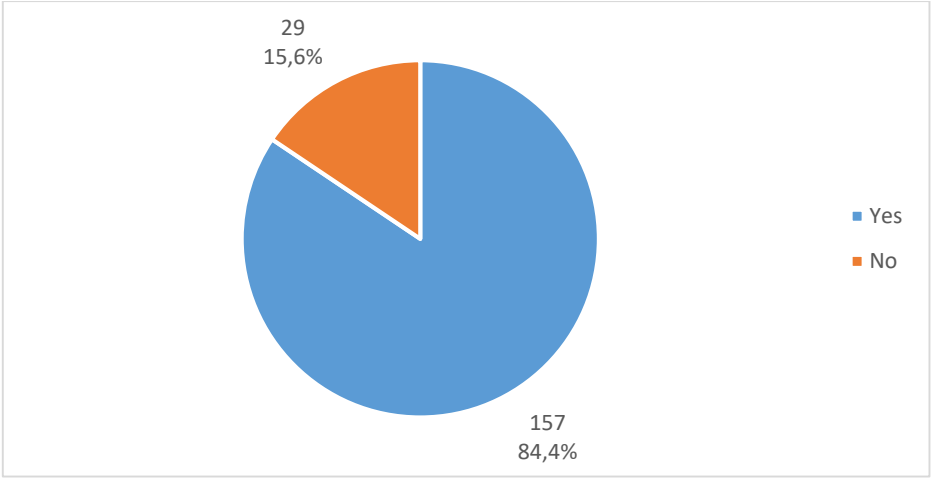


Figure 16 - Results to question 8 of the inquiry.

9. During check-in, did you notice any physical barriers between you and the airport/airline staff?

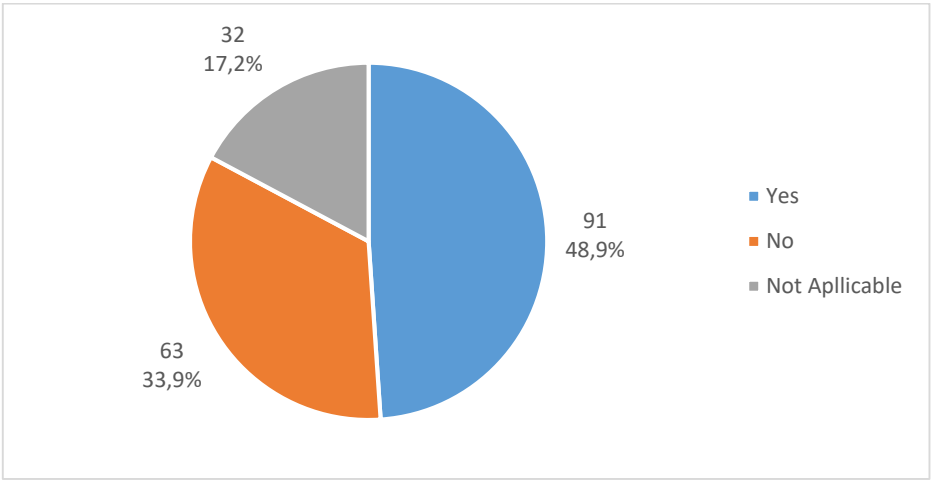


Figure 17 - Results to question 9 of the inquiry.

10. Did you notice any readjustment of the terminal to ensure social distance?

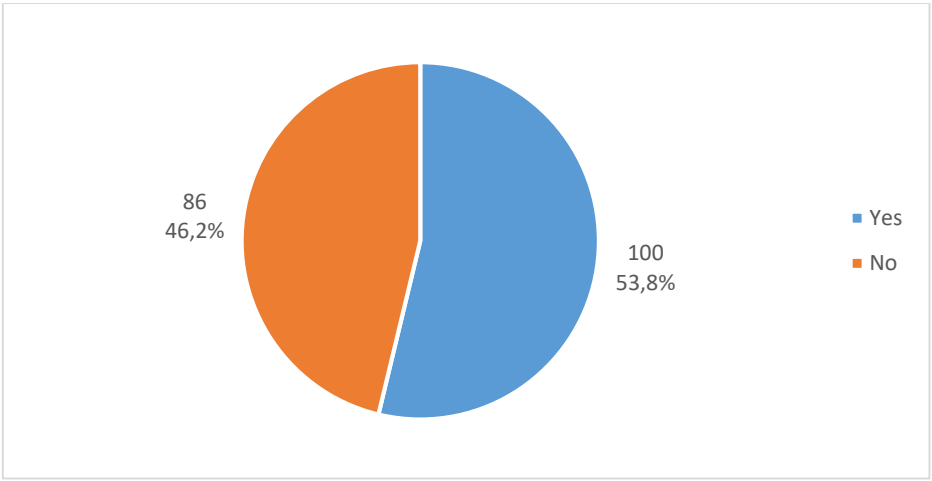
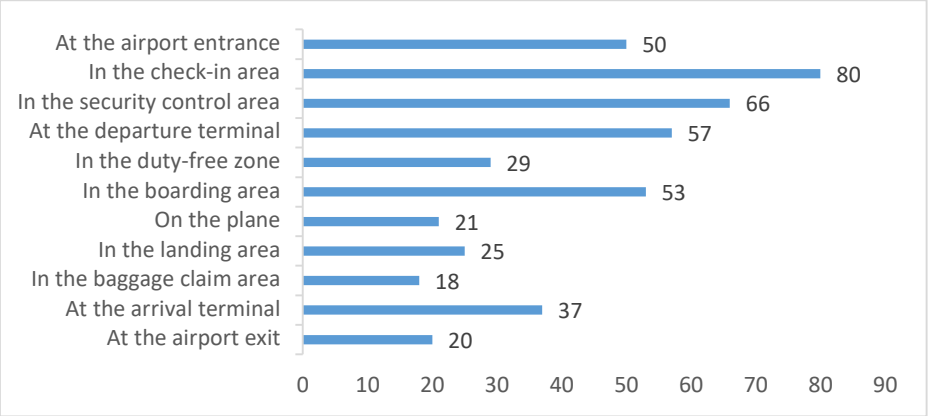


Figure 18 - Results to question 10 of the inquiry.

11. If yes, where did you see these changes? As many answers as necessary.

Table 8 - Results to question 11 of the inquiry.



12. Did you notice more cleaning and disinfection than usual? That is, handrails, doors, benches and other cleaner areas?

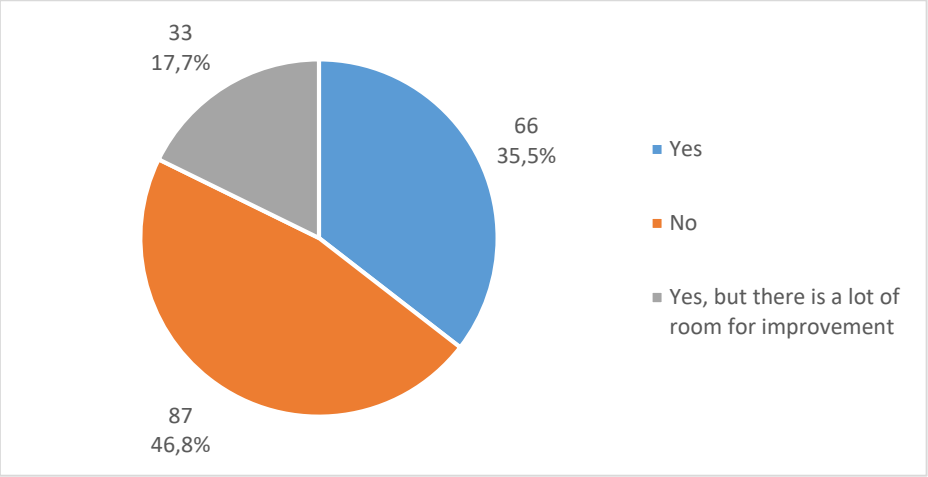


Figure 19 - Results to question 12 of the inquiry.

13. Is the use of a mask mandatory during the entire trip? That is, from the departure terminal to the arrival terminal?

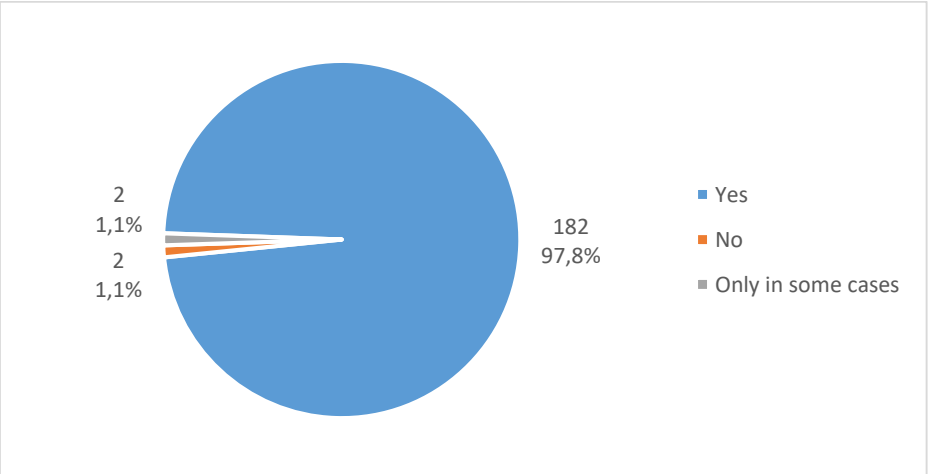


Figure 20 - Results to question 13 of the inquiry.

14. Was your temperature been measured?

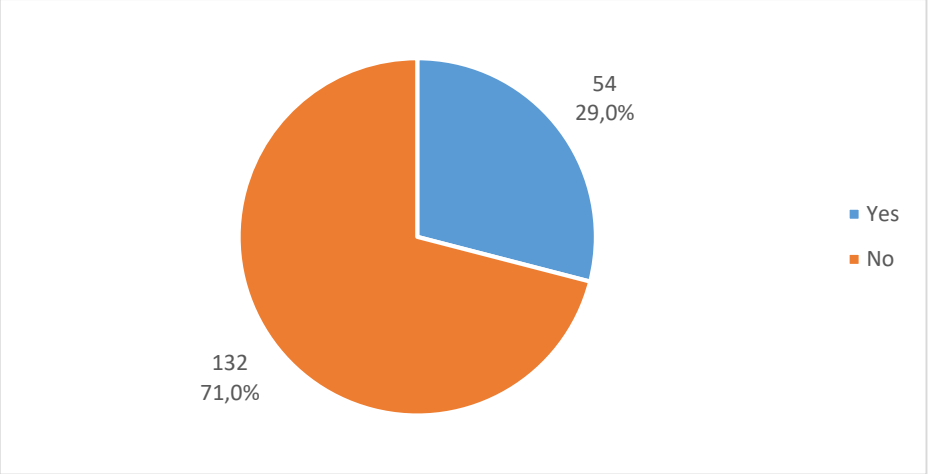
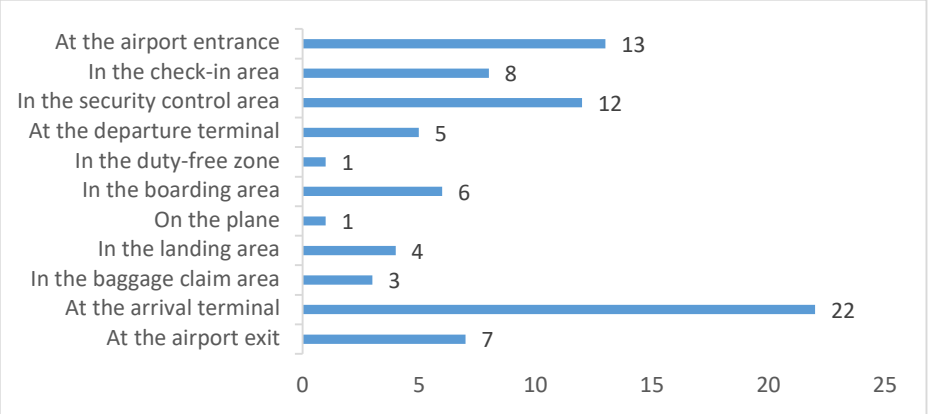


Figure 21 - Results to question 14 of the inquiry.

15. If so, where? As many answers as necessary.

Table 9 - Results to question 15 of the inquiry.



16. Have you shown fever?

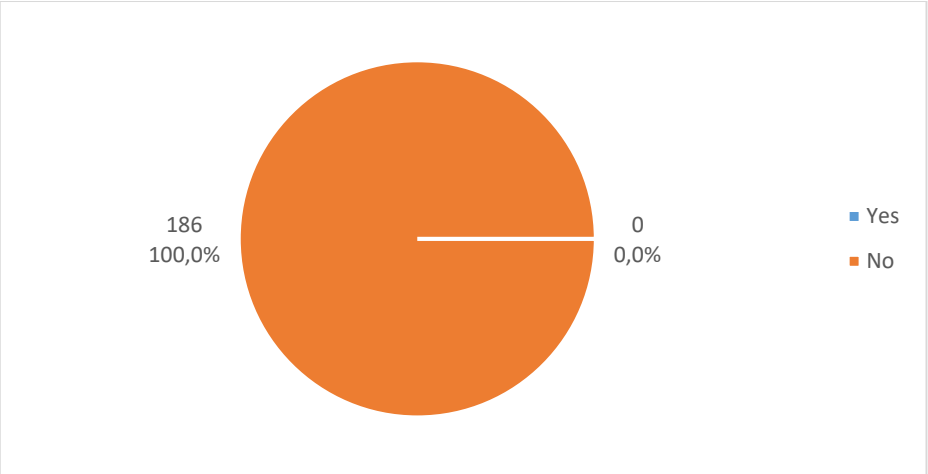


Figure 22 - Results to question 16 of the inquiry.

16.1. Were you sent to a disinfected room?

N/A

16.2. In that room, were any health professionals present?

N/A

16.3. Describe a little about your experience, what you saw, what you felt and the process itself.

N/A

Note: If the answer to 16. is "Yes" then and only then 16.1., 16.2. and 16.3. would be questioned.

17. Did you notice new contactless procedures?

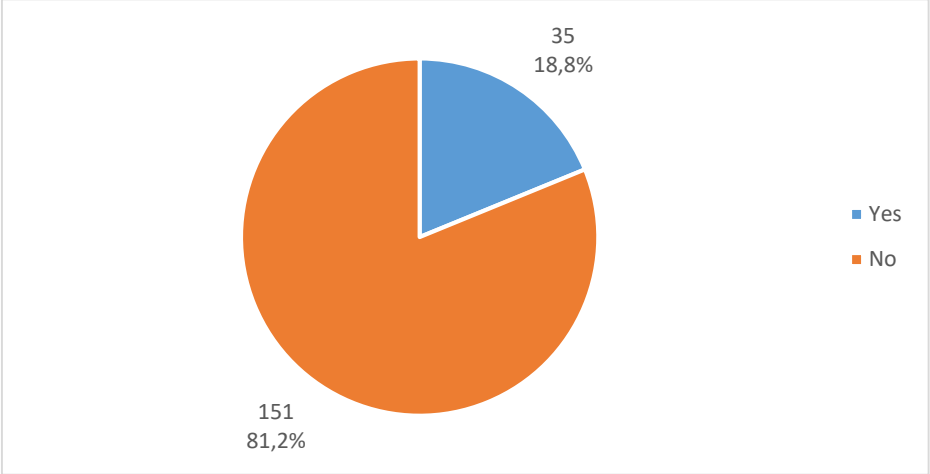


Figure 23 - Results to question 17 of the inquiry.

18. If yes, can you specify?

- Recommended social distance;
- Boarding pass validation by a computer/machine instead by the staff;
- Contactless payments;
- Vaccination certificate checking;
- Contactless check-in;
- Baggage collection using machines;
- Security control contactless procedures;
- Procedures using internet.

19. Have you seen water and masks vending machines?

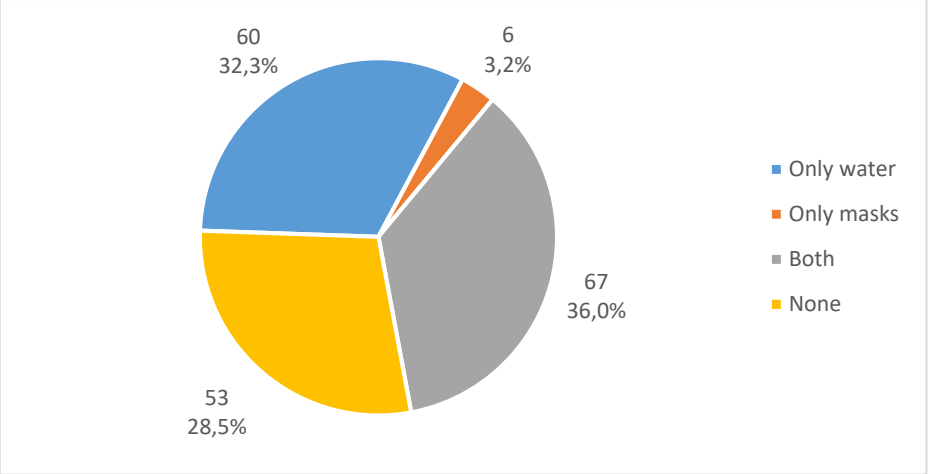


Figure 24 - Results to question 19 of the inquiry.

20. Were there alcohol-based solutions available?

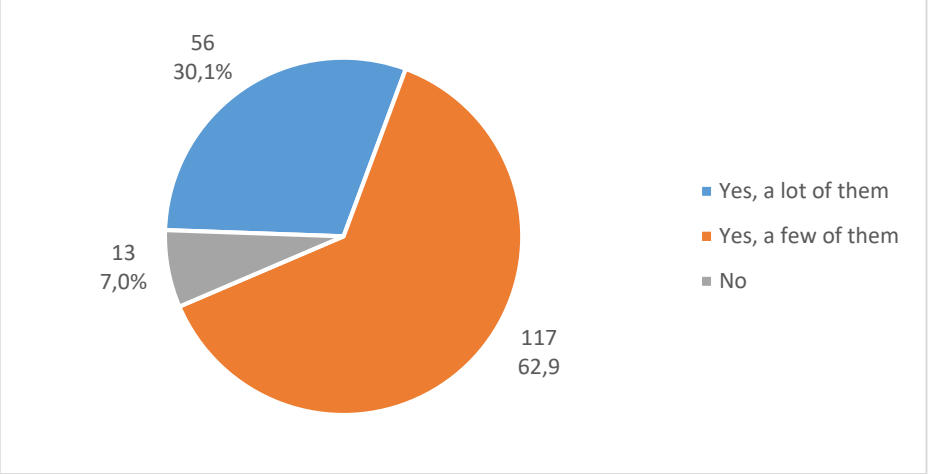


Figure 25 - Results to question 20 of the inquiry.

21. Have you been encouraged to put your carry-on baggage in the airline's hold?

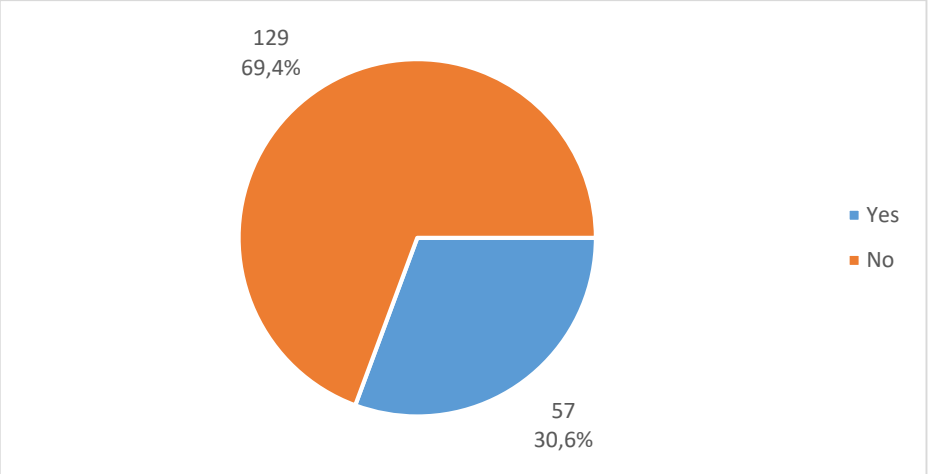


Figure 26 - Results to question 21 of the inquiry.

22. Has your luggage been disinfected?

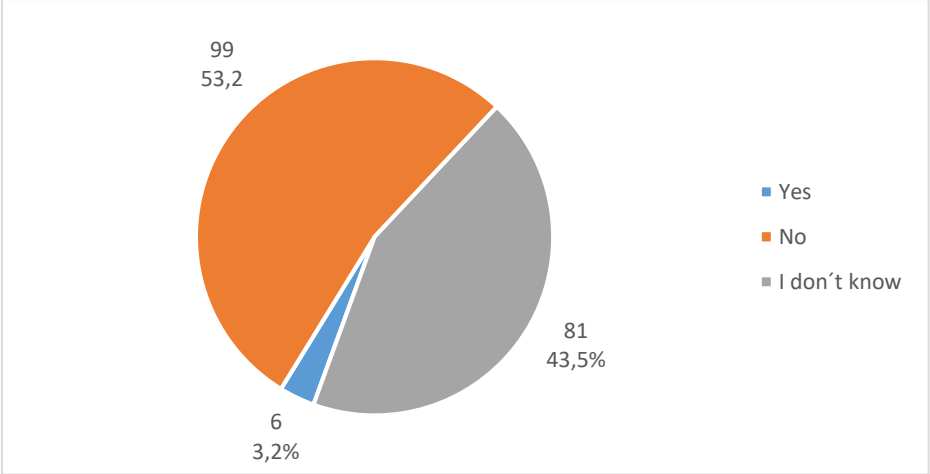


Figure 27 - Results to question 22 of the inquiry.

23. Have you been asked for a vaccination certificate or a negative PCR test?

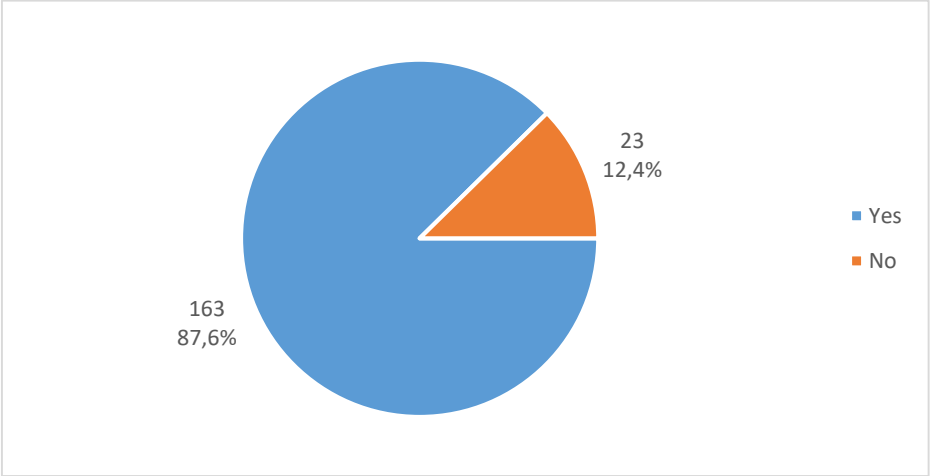


Figure 28 - Results to question 23 of the inquiry.

24. Did you board in queue order?

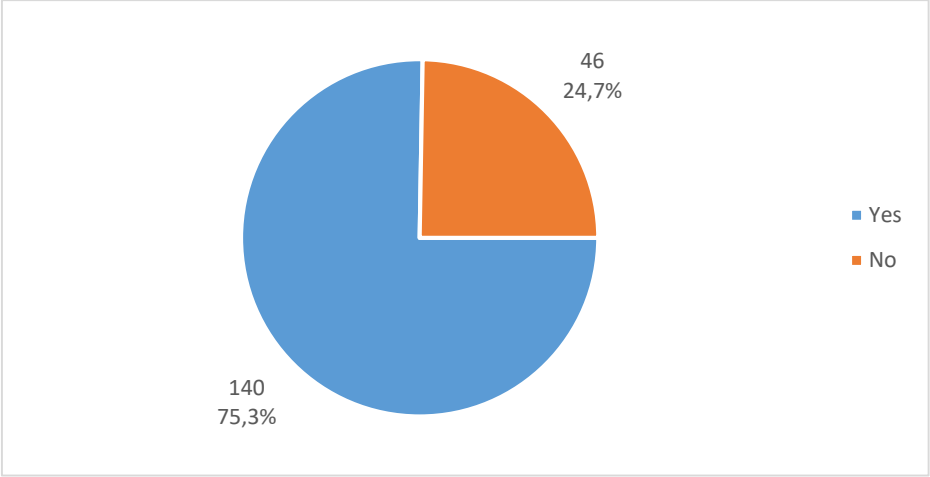


Figure 29 - Results to question 24 of the inquiry.

25. Did you land in the queue order?

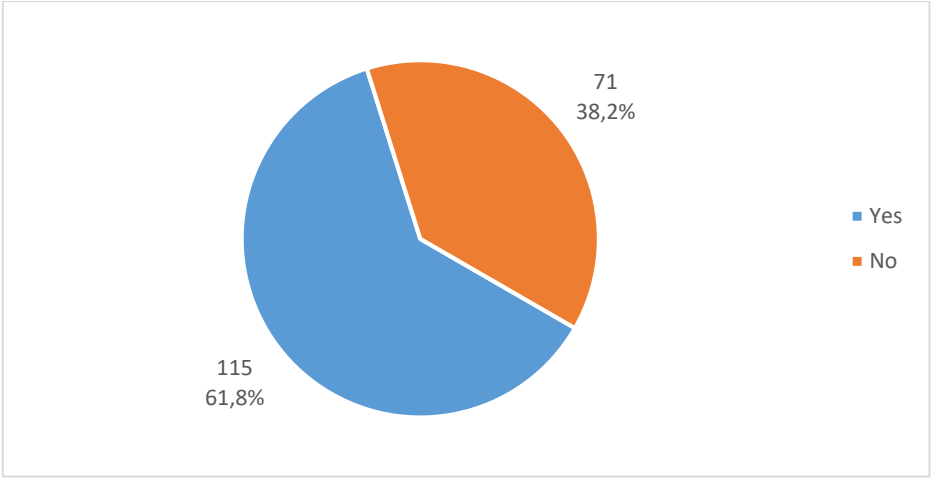


Figure 30 - Results to question 25 of the inquiry.

26. Was, in the plane, a dedicated crew bathroom?

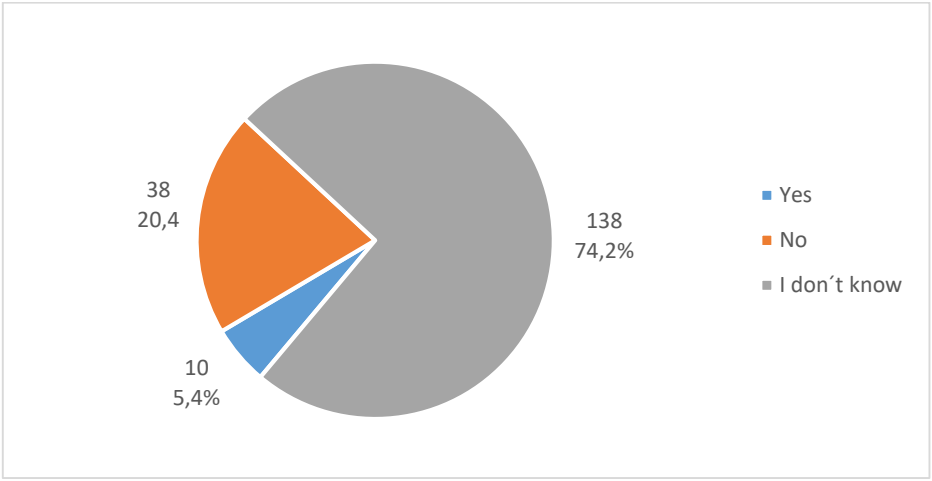


Figure 31 - Results to question 26 of the inquiry.

27. During your trip, were there anyone with symptoms of COVID-19?

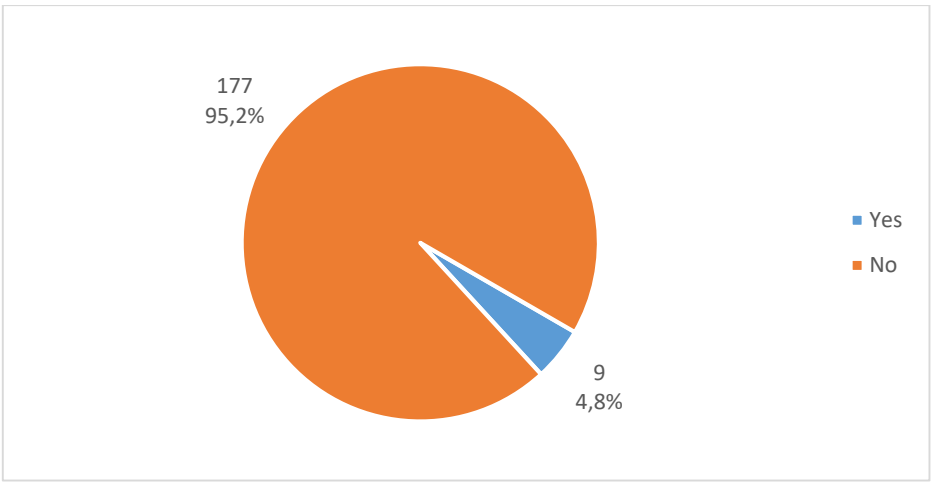


Figure 32 - Results to question 23 of the inquiry.

27.1. Has the person in question been isolated?

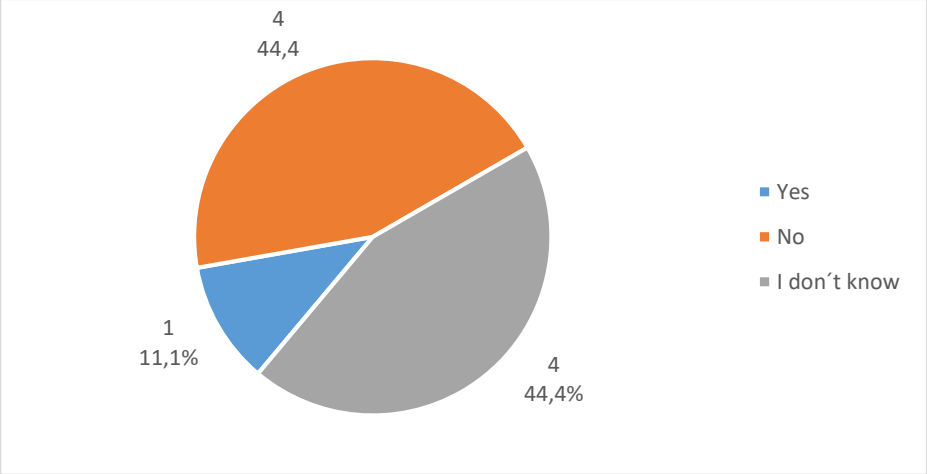


Figure 33 - Results to question 27.1 of the inquiry.

27.2. Was the symptomatic person's family also isolated?

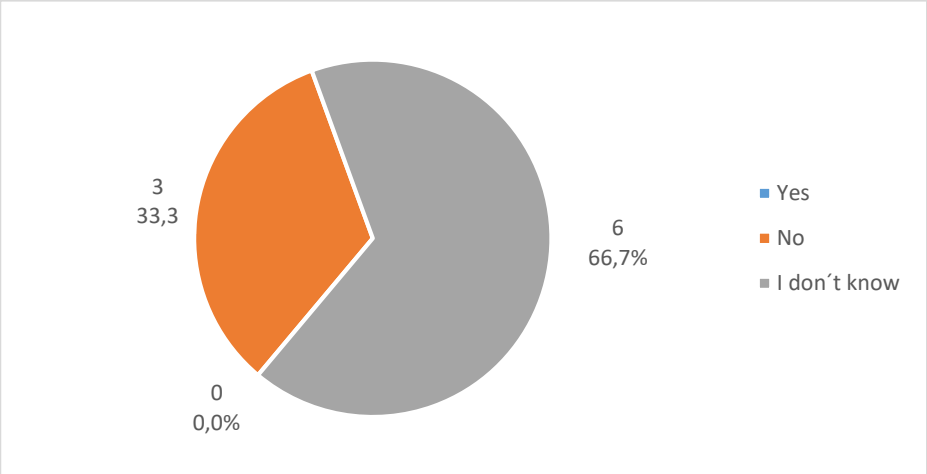


Figure 34 - Results to question 27.2 of the inquiry.

27.3. Has any crew member been assigned to service the symptomatic and his family?

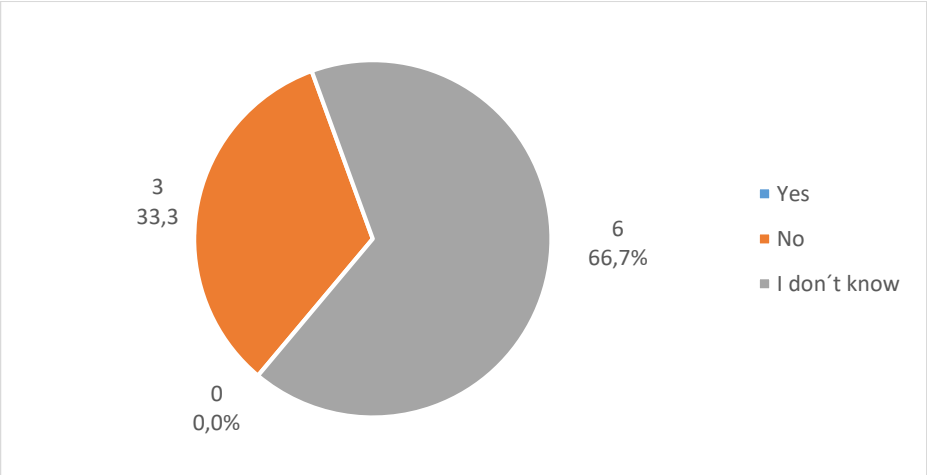


Figure 35 - Results to question 27.3 of the inquiry.

27.4. Did you notice anything distinct in the landing?

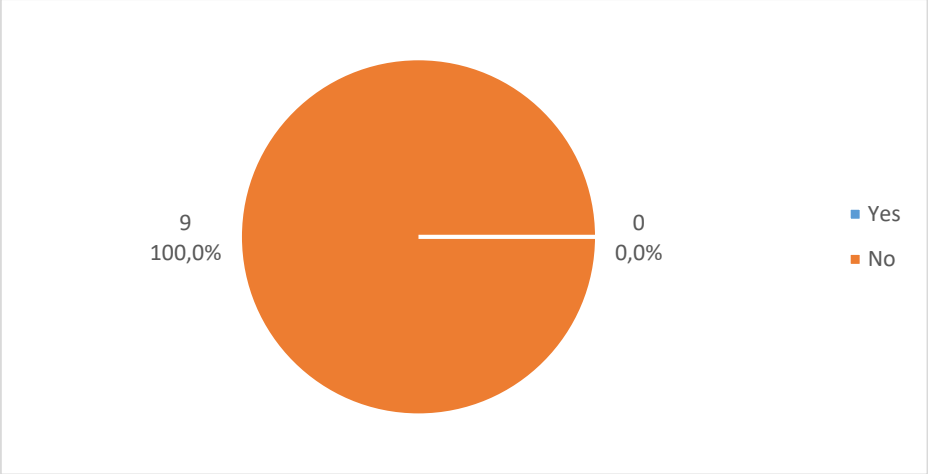


Figure 36 - Results to question 27.4 of the inquiry.

27.5. If yes, could you elaborate further?

N/A

Note: If the answer to 27. is "Yes" then and only then 27.1., 27.2., 27.3., 27.4. and 27.5. would be questioned.

28. How much time did you waste on each stage of your journey beyond the usual?

28.1. At the airport entrance:

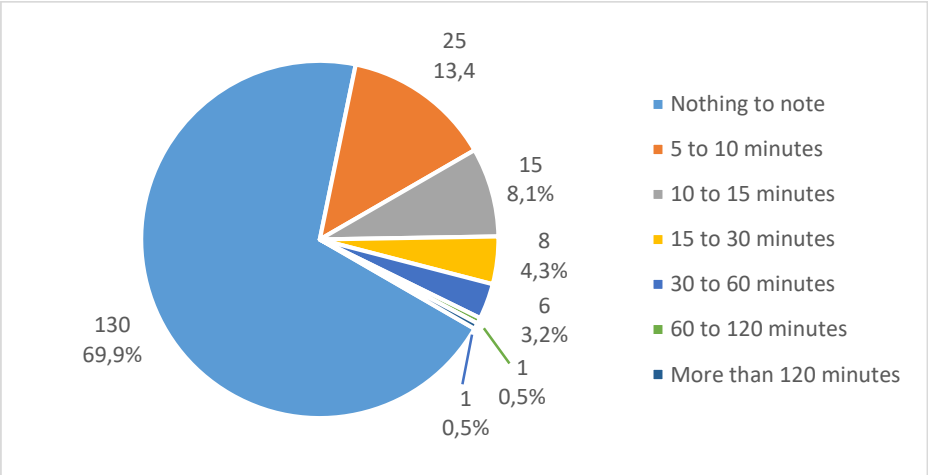


Figure 37 - Results to question 28.1 of the inquiry.

28.2. In the check-in area:

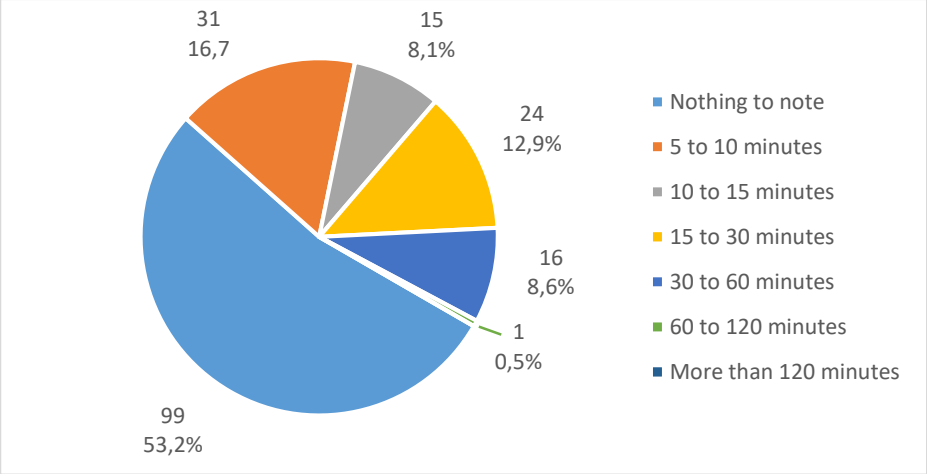


Figure 38 - Results to question 28.2 of the inquiry.

28.3. In the security control area:

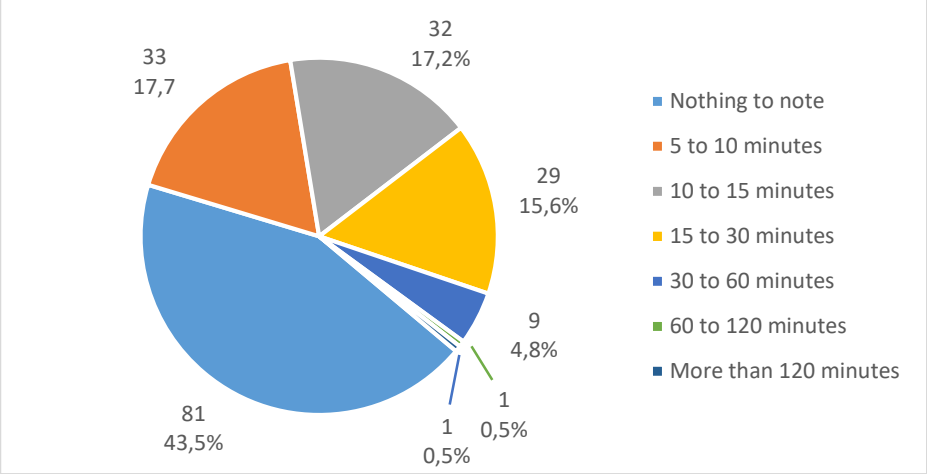


Figure 39 - Results to question 28.3 of the inquiry.

28.4. At the departure terminal:

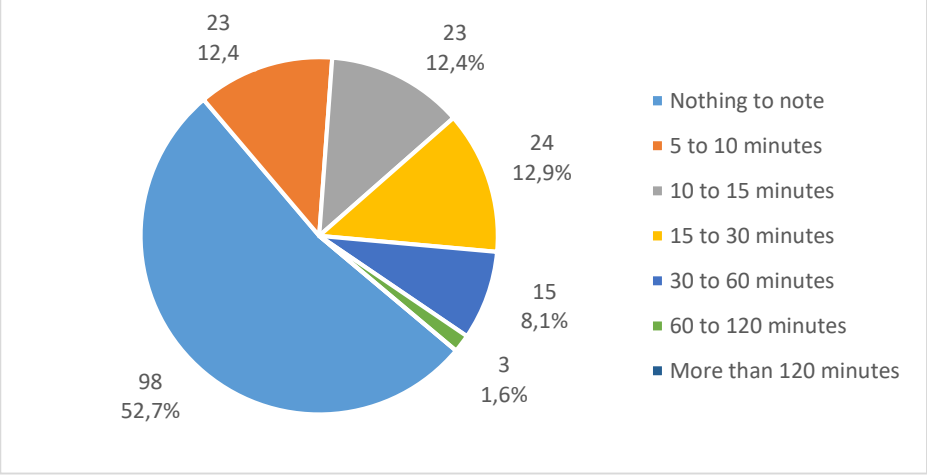


Figure 40 - Results to question 28.4 of the inquiry.

28.5. In the duty-free zone:

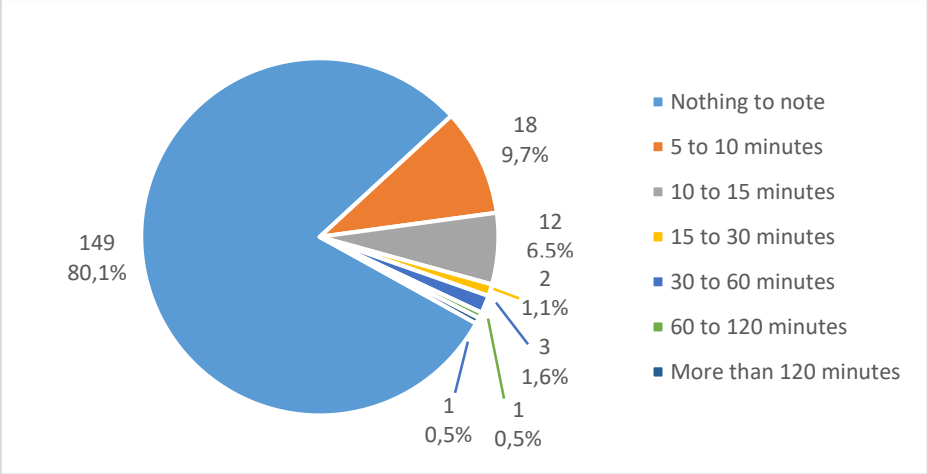


Figure 41 - Results to question 28.5 of the inquiry.

28.6. In the boarding area:

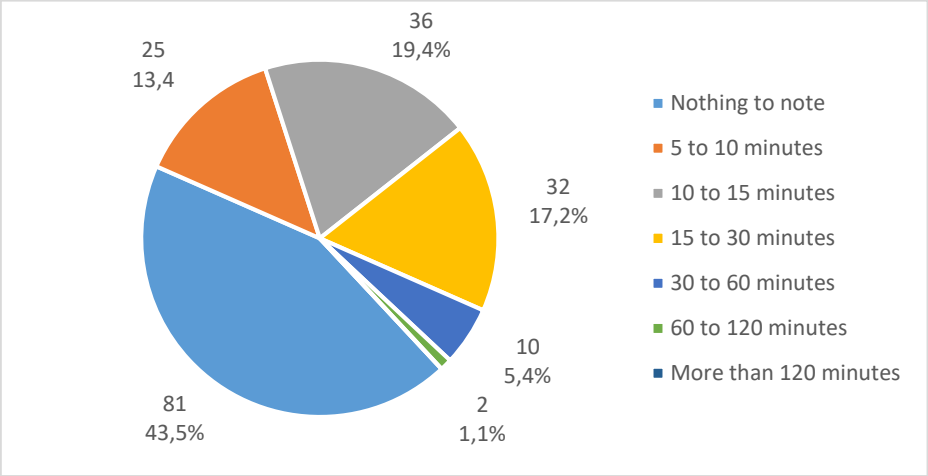


Figure 42 - Results to question 28.6 of the inquiry.

28.7. On the plane:

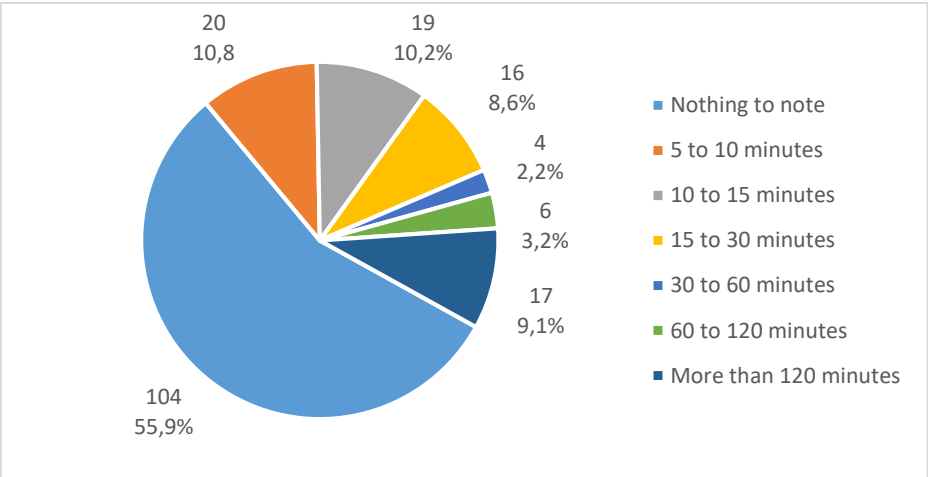


Figure 43 - Results to question 28.7 of the inquiry.

28.8. In the landing area:

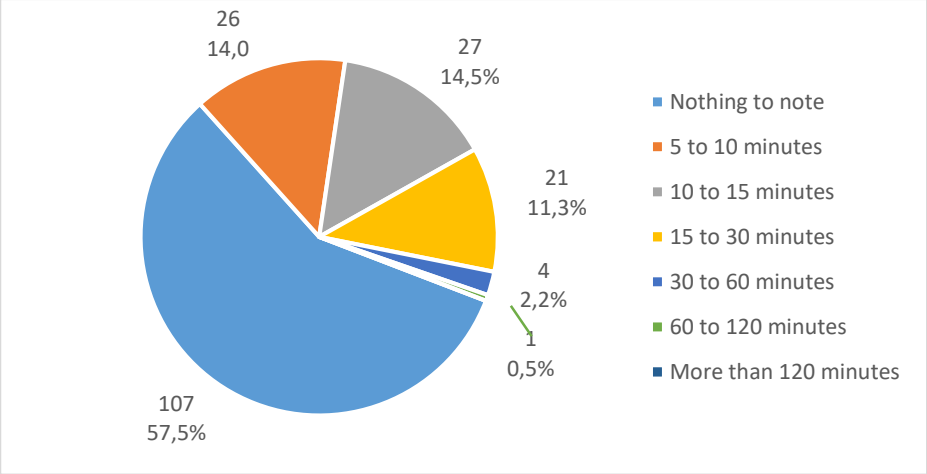


Figure 44 - Results to question 28.8 of the inquiry.

28.9. In the baggage claim area:

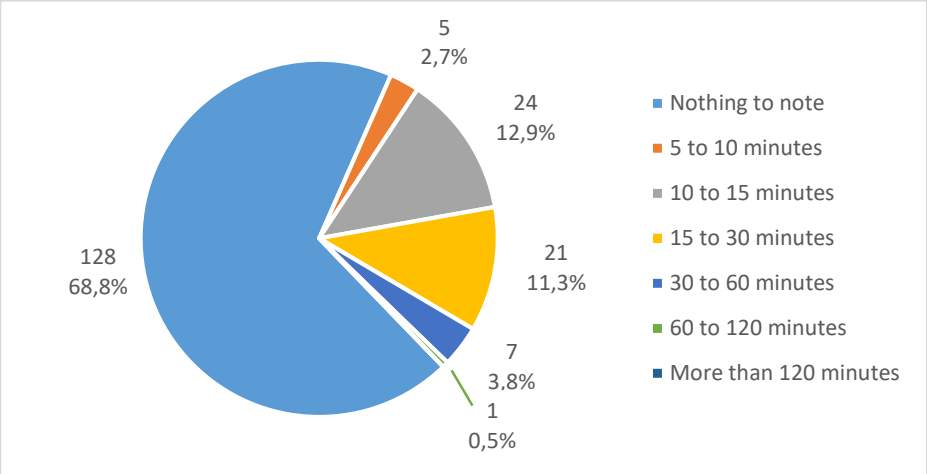


Figure 45 - Results to question 28.9 of the inquiry.

28.10. At the arrival terminal:

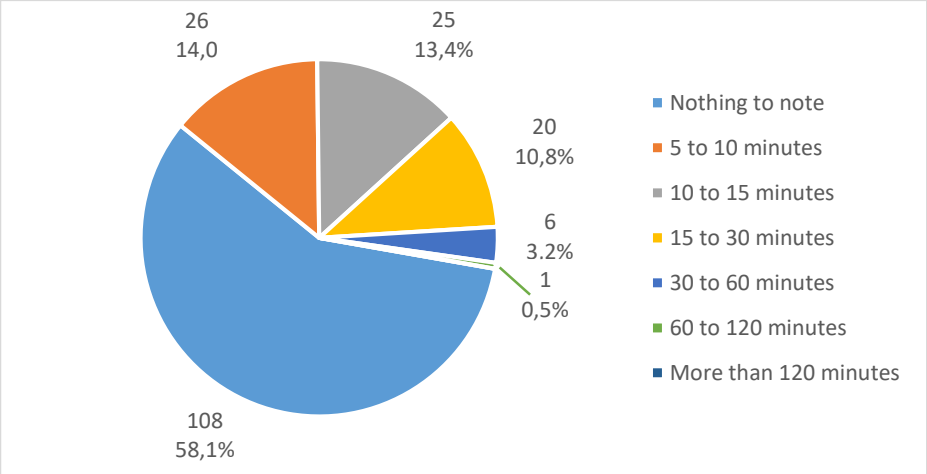


Figure 46 - Results to question 28.10 of the inquiry.

28.11. At the airport exit:

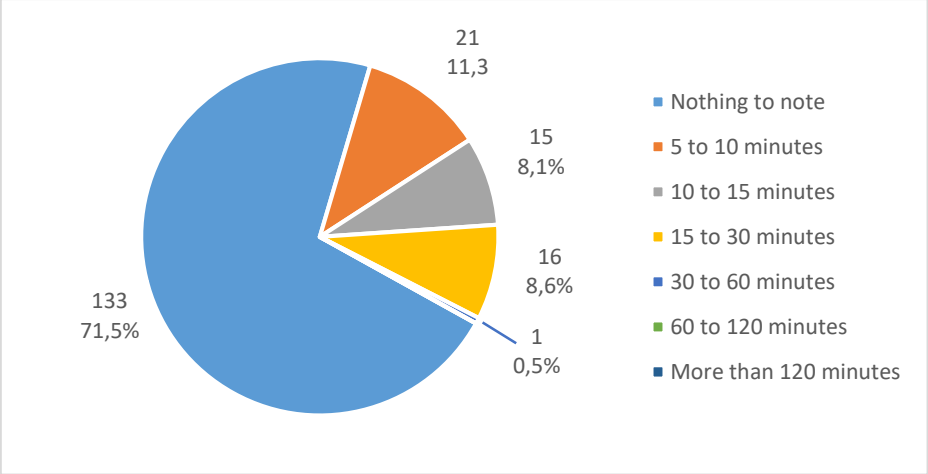


Figure 47 - Results to question 28.11 of the inquiry.

3.4 Conclusions

In short, at the end of 2019, a “viral pneumonia of unknown cause” appeared in Wuhan province, China, which would later be called COVID-19 and whose virus was named SARS-CoV-2. This disease quickly spread across the globe, leaving an endless number of infected and dead in its path, as well as serious marks on the world economy and in all its sectors. In this way, aviation was no exception, having even been one of the most affected sections due to its close connection with the tourism. This sector, was the most harmed, in large part, due to restrictions imposed by governments to curb the growing waves of infected. Although COVID-19 is not completely extinct, vaccination programs, especially in developed countries, have laid the foundations for the possibility of returning to the “new normality” and, therefore, to the world economic recovery.

However, the constant mutations of SARS-CoV-2 diminish the effectiveness of vaccines. As stated by the President of the EC, Professor Didier Houssin. "We are in a race between the virus which is going to continue trying to mutate in order to spread more easily, and humanity which has to try to stop its spreading” [67].

In order to assess the risk assessment capacity of the airports, a series of interviews were conducted with experts responsible for airport management, more specifically, the measures and protocols implemented to combat COVID-19. The interviews aimed to find out whether the airports' contingency plans were prepared and sufficiently scrutinized to deal with the pandemic crisis or whether they had gaps that had to be filled. Also, the interviews aimed to verify the homogeneity, or lack thereof, in the implementation of

measures against COVID-19. On the other hand, the surveys were essentially intended to verify, from the user's point of view, the main changes felt by passengers. The aim was therefore to get an idea of the impact of the measures on the day-to-day operations of airports. The results were presented in this chapter, and their analysis is contained in chapter 4, the analysis of results.

Chapter 4 – Analysis of Results

The analysis of the results of this dissertation will be composed of two distinct studies, carried out based on the answers obtained from interviews with experts in airport management as well as feedback from surveys submitted to a large group of passengers.

The purpose of the interviews was to verify whether or not airports and their contingency plans were prepared to deal with a pandemic crisis such as COVID-19. Whether or not the measures implemented in different airports across the globe were identical and if they were influenced by the culture or the geographical area. Should they be different, whether they became closer over time or more and more distant. Also to find out if some measures were abandoned because they were not very efficient when the cost-benefit ratio was evaluated. Finally, whether or not we will return to pre-pandemic operational and monetary levels, and if so, when?

The objective of the surveys was to analyse the impact of the measures implemented against COVID-19 on the airport's daily operations. For this analysis, the opinions and sensations of passengers, were crucial, in order to investigate if the implementation plan was correctly put into practice by the airports and if theory aligned with practice.

4.1 Interviews

In this section, an analysis of the answers obtained during the interviews will be made. Unfortunately, it was not possible to obtain answers from some of the airports. The analysis will be carried out question by question.

1. Does the airport where you work have an airport emergency plan or something similar in place?

The answers of the experts were conclusive since all airports have emergency plans, even being mandatory, according to the regulations. The entities responsible for drawing up, updating, supervising and executing the plan is the aeronautical authority, which varies according to the country where the airport is located. In the USA, it may even be regulated by the state rather than the federal government.

2. Did the airport emergency plan include measures and procedures to control infectious and easily transmitted diseases?

In Portugal, contingency plans did not cover a pandemic situation, so it was necessary to create procedures to deal with a health crisis.

Again, the answers were very homogeneous, with all specialists mentioning the existence of protocols and measures against infectious diseases through the health emergency section.

2.1 If so, were they implemented exactly according to the emergency plan or were adjustments needed? Have any gaps been detected in the emergency plan?

At all airports, where emergency plans included a section for infectious diseases, amendments to contingency plans were necessary, either because the pre-established measures were too superficial, or because there was an evolution of the pandemic and inherently an evolution in the available technologies.

2.2 If not, how the airport responded to COVID-19? Has it ceased its activity temporarily or has it implemented emergency measures?

Initially, the airport ceased its activities, operating only humanitarian, repatriation and cargo flights. Then, with the emergence of IROPS (Irregular Operations), procedures were put in place to allow the airport to operate.

3. Were these measures maintained from day one (the beginning of the pandemic situation) to the present day, or were adjustments made as the pandemic unfolded?

All airports had to readjust their measures over time. In fact, the pandemic was not static, as the number of cases and deaths varied all the time. There were moments of total lack of control, when the number of daily cases reached unprecedented peaks and others when the pandemic was more or less under control. The emergence of more efficient technologies also contributed to this volatility of measures. In the case of the USA in particular, these changes were even more accentuated due to the fact that the regulatory bodies were state-owned. Therefore, within the same country and simultaneously, different measures were implemented.

4. If adjustments were made, why were they necessary?

The most common case is the vaccination certificate. At the beginning of the pandemic and because there were no vaccines, this certificate was not required, but with the emergence of vaccines, this became a mandatory prerequisite globally. On the other hand, several new technologies have been adopted over time.

5. Who decided on the measures to be implemented at the airport? Management or regulatory organizations such as ICAO and EASA?

All experts agree that there was no one entity entirely responsible for implementing the measures against COVID-19. Thus, it was a joint effort among several regulatory bodies, the government, the ministry of health, and the airports. However, in some countries, the weight of the government was higher like in Canada, Mexico or in Portugal). In countries, such the United States and Argentina, airports having more control.

6. What measures have been implemented?

Measures implemented in Mexico, Argentina and in Portugal were as follows:

- Mandatory use of masks and protective gear;
- Floor markings to ensure social distancing;
- Temperature checkpoints;
- COVID-19 testing and immunity passports;
- Verification of transit passengers.

In addition to the negative PCR, 72 hours before the flight, whose control was the airline's responsibility, in Argentina, a COVID-19 antigen test was done on the departure from the airport. After seven days, the passenger had to repeat a PCR test in order to leave quarantine. These measures upon arrival at the airport were only seen by this country. In Mexico, it should be noted that aircraft not equipped with HEPA filters were not allowed to land. In Portugal, a system of wristbands has been established, whereby a passenger travelling within national territory has a green wristband with which there is no obligation to perform a PCR test, a passenger coming from abroad has a blue wristband which is controlled by the SEF (Foreigners and Borders Service).

7. Have these measures been effective in detecting patients infected with SARS-CoV-2? I.e., how much has the probability of SARS-CoV-2 positive passengers traveling through the airport decreased?

Although it is difficult to identify the actual effectiveness of the measures, experts seem to agree that the concept of "layered mitigation measures", has been successful in significantly reducing the risks of contagion in air transport. Ezeiza airport, in particular, corroborates this theory, with small percentages of positive antigens on arrival.

8. Have these measures proven to be cost effective? Was any of the measures abandoned after proving to be unprofitable? If so, what was it?

According to the responses, there were cost-effective measures and others that were not. The most common case was temperature controls, which, after proving to be very

inefficient, were abandoned all over the world. This measure worked more as a means of instilling confidence in passengers during the flight than as an effective method of detecting possible SARS-CoV-2 positives.

9. Do you believe these were the best possible steps to take, so to stop COVID-19 or is there scope for improvement?

For this question, only a single expert opinion could be gathered. According to him, the 2h interval between flights was the worst measure implemented, being excessive and very harmful for the Argentine economy. In the Portuguese expert's opinion, the measures implemented were those that, as far as possible, complied with what was stipulated.

10. If you believe that other measures should have been implemented, what would they be?

In light of the previous question, the only opinion gathered is in favour of more efficient airport logistics to reduce the time gap between flights.

11. What was the total cost of the measures put in place to stop the spread of the virus?

For confidentiality reasons this figure was not disclosed for any of the airports.

12. To what extent has the airport been affected economically during this pandemic crisis and what was the loss recorded during this period, since the beginning of the pandemic until the present moment?

The only feedback received to this question, referred to an estimated $5.3 billion loss to the Mexican airline industry and 534,000 jobs at risk due to the COVID-19 pandemic.

13. At the operational level, what was the associated cost, i.e. what was the traffic reduction at the airport? Has your airport returned to pre-pandemic values in recent months?

Domestic aviation market suffered less than the international one, and should recover more quickly. In addition, the freight sector was less impacted than passenger transport, due to the restrictions imposed by governments on passenger traffic and the increase in online shopping. Even so, freight transport recorded losses due to the closure of physical shops.

14. If not, when do you think your airport will return to these values?

In Mexico, at the time of publication of [64] it was believed that the recovery of passenger traffic would take place in 2021 and of freight traffic in 2020. However, it is not known when the pre-COVID-19 values will be fully recovered. In Argentina, in November 2021, it was believed that this recovery would take place, in 2025. Portugal estimates a recovery for 2024.

4.2 Surveys

Here, an analysis will be made of the results obtained from the surveys, which appear in the case study chapter (3) in the surveys section (3.4).

1. Have you recently travelled by plane (since January 2021)?

There were 62% "YES" answers and 38% "NO" answers. Apparently, a large part of the population, travelled by air in 2021. However, and taking into account that these questionnaires were largely made available to individuals linked to air transport, such as businessmen, aeronautical engineering students or aeronautical entities, one can note a certain decrease in air travel in relation to the pre-COVID period.

2. What was the main airline that you flight with?

From a universe of 186 answers, 108 (58.1%) refer to the five most used airlines, being Ryanair at 24.7% with 46 individuals, TAP Air Portugal at 11.8% with 22 individuals; EasyJet at 9.1% with 17 individuals); Lufthansa at 7% with 13 individuals; Air France at 5.4% with 10 individuals and KLM at 4.8% with 9 individuals. On the other hand, 78 answers (41.9%) refer journeys made through other 36 carriers. In this way, it will be possible to infer the relations of these airlines with some of the measures implemented below.

3. What was the departure airport?

Among the most used departure airports, the top 5, registered 103 answers (55.4%), these being, the following:

- Oporto Francisco Sá Carneiro Airport, at 26.3%, with 49 replies;
- Lisbon Humberto Delgado Airport, at 16.7%, with 31 replies;
- Paris Roissy Charles de Gaulle Airport, at 5.4%, with 10 replies;
- Madrid Barajas Airport, at 3.8%, with 7 replies;
- Bordeaux Mérignac Airport, at 3.2%, with 6 replies.

There were a large number of journeys, totalling 80, starting from Oporto and Lisbon airports and a more homogeneous range of journeys from the other airports (106 journeys spread over 54 airports).

4. What was the airport of arrival?

Among the most used arrival airports, the top 5 registered 49 answers (26.3%), these being, the following:

- Lisbon's Humberto Delgado Airport, with 16 replies (8.6%);
- Francisco Sá Carneiro Airport in Oporto, with 11 replies (5.9%);
- João Paulo II airport, in Ponta Delgada, with 8 replies (4.3%);
- Zaventem airport, in Brussels, with 8 replies (5.3%);
- Funchal Cristiano Ronaldo Airport, with 6 replies (3.2%).

On the other hand, 137 replies (73.7%) were distributed between the 87 other airports.

5. Where did you stop? If applicable, insert all airports where you stopped.

Since a large part of the flights were made without stopovers, only 30 answers were recorded to this question, of which 14 individuals (46.7%) had stopovers at the following 5 airports:

- Frankfurt Airport with 5 Persons (16.7%)
- International Airport II Caravaggio with 3 persons (10%)
- Istanbul Airport with 2 Persons (6, 7%)
- International Airport Franz Josef Strauss with 2 Persons (6, 7%)
- Amsterdam Schiphol Airport with 2 Persons (6, 7%)

The remaining 16 responses (53.3%) were split between 16 other airports.

6. Were you previously informed about the measures and procedures in the airport by the airline?

Out of the 186 replies, 156 answers (83.9%) were "YES" and 30 responses were "NO". This indicates that a large part of the passengers knew, beforehand, the rules and procedures that they had to respect during their journey. After analysing the negative answers to this question, it was also found that 10 out of 46 passengers (21.7%), who travelled with Ryanair, were not informed in advance of the measures. Similarly, 4 out of 10 (40%), who travelled with Air France, 3 out of 8 (37.5%), who travelled with SATA-

Azores Airlines and 2 out of 3 (66.7%), who travelled with Air Europa. Cases where there was a single negative response within the airline were not considered.

7. Did you fill out a COVID-19 tracking form?

To this question it was found that 153 respondents (82.3%) answered "YES" against 33 negative answers (17.7%), which reveals a consequent availability of COVID-19 tracking forms.

8. Did you check in online?

It can effectively be seen that a large number of passengers checked in online, a recurrent resource since the pandemic broke out. The data shows 157 answers (84.4%) "YES" against 29 answers (15.6%) "NO". An analysis was also made of passengers who did not check in online, of which 5 out of 10 (50%) travelled with Air France, 4 out of 8 (50%) travelled with SATA (Azorean Airlines), and 2 out of 3 (66.7%) travelled with Croatian Airlines. These were therefore the companies that adopted this measure the least.

9. During check-in, did you notice any physical barriers between you and the airport/airline staff?

There were 91 answers (18.9%) "YES", 63 answers (33.9%) "NO" and 32 answers (17.2%) "NOT APPLICABLE". Thus, almost half of those questioned reported the existence of physical barriers.

10. Did you notice any readjustment of the terminal to ensure social distance?

Regarding the readjustments in the terminals, such as floor markings, blocked benches & optimization of spaces to ensure social distancing, 100 people (53.8%) felt that an effort was made by the airport against the 86 people (46.2%) whose opinion was the opposite.

11. If yes, where did you see these changes? As many as answers as necessary.

The vast majority of adjustments were observed in the check-in area (80 replies), followed by the security control area (66 replies) and the departure terminal (57 replies). On the other hand, the areas where these adjustments were least noticeable were in the aircraft (21 answers), at the airport exit (20 answers) and finally in the baggage claim area (18 answers). Thus, it was noted, in general, a certain decrease in the concern of airports to ensure social distancing when passengers arrive compared to the pre-flight processes. Thus, from the passenger's point of view, as the journey progressed, social

distancing was less and less guaranteed. It should be noted that in this question the respondent could choose as many options as he/she thought there had been changes.

12. Did you notice more cleaning and disinfection than usual? That is, handrails, doors, benches and other cleaner areas?

There were 87 answers (46.8%) "YES", 66 answers (35.5%) "NO" and 33 answers (17.7%) "YES, BUT THERE IS MUCH ROOM FOR IMPROVEMENT". In other words, a large proportion of the respondents did not notice any difference between the disinfection of touch-prone surfaces, during 2021, when compared with the pre COVID-19 period. These results can be explained by the fact that the most thorough disinfection of both airports and aircraft is done at night or during periods of low concentration of flights, in order to disturb passenger traffic as little as possible.

13. Is the use of a mask mandatory during the entire trip? That is, from the departure terminal to the arrival terminal?

One question where there seems to be no debate on the implementation of the measure is in relation to the use of masks. 182 respondents (97.8%) answered that this measure was mandatory during the entire trip. There were only 2 negative answers (1.1%) and 2 answers (1.1%) "Only in some cases". These results reflect the fact that the use of masks is the most cost-effective measure, widely adopted not only in aviation but in all other areas of life in society.

14. Was your temperature been measured?

Regarding temperature taking, we have 132 passengers (71%) who say they have not gone through this procedure, against 54 passengers (29%) checked. These values reveal a lower cost/effectiveness ratio for this measure, having been abandoned with the course of the pandemic in most airports worldwide. Its implementation was more aimed at alleviating passengers' concerns than for its efficiency in detecting possible SARS-Cov-2 positives.

15. If so, where? As many answers as necessary.

The vast majority of temperature measurement locations were identified in the arrival terminal, with 22 answers, followed by the airport entrance (13 answers) and the security control area (12 answers). On the other hand, the areas where the least temperature measurements were taken were in the aircraft (1 answer), in the duty free area (1 answer) and finally in the baggage claim area (3 answers). Thus, it was noted that temperature

measurements were taken both in the initial stages of the journey, in order to avoid carrying positive passengers, and on arrival in the country of destination, in order to isolate positive cases that may have gone unnoticed during the flight. It should be noted that in this question the respondent could choose as many options as he/she thought there had been changes.

16. Have you shown fever?

In this question the results were unanimous, with 186 respondents (100%) answering negatively. This highlights the lack of efficiency of the method. Given the results, there were no answers to questions 16.1, 16.2 and 16.3.

16.1. Was it sent to a disinfected room?

N/A

16.2. In that room, were any health professionals present?

N/A

16.3. Describe a little about your experience, what you saw, what you felt and the process itself.

N/A

Note: If the answer to 16, was "YES" then, and only then, would 16.1, 16.2 and 16.3, be questioned.

17. Did you notice new contactless procedures?

To this question, we got 35 answers (18.8%) "YES" and 151 answers (81.2%) "NO". In light of the results obtained, we conclude that there was no significant increase in contactless procedures, despite the virus spreading through contact.

18. If yes, can you specify?

Among the respondents' answers were the following:

- Recommended social distance;
- Boarding pass validation by a computer/machine instead by the staff;
- Contactless payments;
- Vaccination certificate checking;
- Contactless check-in;

- Baggage collection using machines;
- Security control contactless procedures;
- Procedures using internet.

19. Have you seen water and masks vending machines?
Regarding mask and water dispensers, 60 respondents (32.3%), say they have noticed only water machines, 6 individuals (3.2%) point to the distribution of only masks, 67 people (36%) to the existence of both supplies and 53 cases (28.5%) to neither.

20. Were there alcohol-based solutions available?

Most of those surveyed (73, 93%) verified the existence of alcohol gel dispensers for free use by the passenger. There were 56 answers (30.1%) "YES, MANY OF THEM", 117 answers (62.9%) "YES, SOME OF THEM" and 13 answers (7%) "NO". Alcohol gel was, therefore, a widely used measure in the fight against the pandemic.

21. Have you been encouraged to put your carry-on baggage in the airline's hold?

Here we have 129 negative answers (69.4%), against 57 positive answers (30.6%). This shows that it was not a measure widely adopted by airlines. An independent analysis of the positive responses and respective airlines was also carried out. We therefore highlight the following cases: 12 out of 46 (26.1%) passengers who travelled with Ryanair, 9 out of 22 (40.9%) passengers who flew with TAP Air Portugal and 3 out of 8 (37.5%) passengers who travelled with SATA (Azores Airlines). These were the airlines that opted most for this measure, with special mention for the 40.9% recorded by TAP Air Portugal.

22. Has your luggage been disinfected?

Baggage disinfection was not a measure verified by passengers, with only 6 people (3.2%) responding positively. 99 people answered “NO” and 81 people (43.5%) answered “I DON’T KNOW”. Measure of little benefit in terms of cost/efficiency, according to the results obtained, having been abandoned after some time. Another explanation is related

with the fact that these disinfections are carried out after baggage collection, that is, without the presence of the passenger.

23. Have you been asked for a vaccination certificate or a negative PCR test?

The 163 responses (87.6%) in the affirmative versus the 23 (12.4%) in the negative show that this was a measure widely implemented in the fight against COVID-19.

24. Did you board in queue order?

Regarding boarding, 140 passengers (75.3%) confirm that the process took place in order, against 46 passengers (24.7%) who say they have not noticed any change in relation to the pre-COVID-19 procedure. It is worth remembering that when “boarding in queue order”, passengers are called in order of rows, from the tail to the nose, i.e., in decreasing order of number of seats. An analysis of boarding by order was also carried out, and the following results were collected: 14 out of 46 (30.4%) passengers who travelled with Ryanair stated that boarding was not carried out in order of rows. The same situation occurred with 5 out of 22 (22.7%) passengers who travelled with TAP, 4 out of 17 (23.5%) with EasyJet and 3 out of 10 with Air France. Thus, the air carrier that least adopted this measure was Ryanair, followed by Air France.

25. Did you land in the queue order?

Compared to the boarding procedure, there is less concern to ensure the order of the queues during disembarkation. The 115 answers (61.8%) “YES” against the 71 answers “NO” represent just that. This disparity is explained by the fact that disembarkation is naturally more orderly, with limited space in the cabin and the fact that there is a single circulation aisle. Likewise, an analysis of disembarkation was carried out and it was found that 24 out of 46 (52.2%) of passengers who travelled with Ryanair say that disembarkation was not carried out in an orderly manner. The same situation occurred with 8 out of 22 (36.4%) passengers who travelled with TAP, 5 out of 10 (50%) who travelled with Air France, 3 out of 8 (37.5%) who travelled with SATA (Azores Airlines) and 3 out of 3 (100%) who travelled with Turkish Airlines. It is thus concluded that this was not a measure widely applied by Turkish Airlines and Ryanair.

26. Was, in the plane, a dedicated crew bathroom?

Analysing the 10 "YES" answers (5.4%), the 38 "NO" answers (20.4%) and the 138 "Don't know" answers (74.2%), we conclude that this measure has not been widely adopted by airlines. Taking into account that there are several toilets inside an aircraft and that, on

short flights, most passengers do not use them, it is easy to understand the large number of "Don't know" answers.

27. During your trip, were there anyone with symptoms of COVID-19?

There were 9 (4.8%) "YES" answers against 177 (95.2%) "NO" answers. These results show that most of the symptomatic cases were detected in the early stages of the process and that the probability of a symptomatic travelling is very low. It should be taken into account that the symptoms of flu are very similar to those of SARS-Cov-2, so the percentage could be even lower. The analysis of the detection of asymptomatic cases is not reflected in this chart.

27.1. Has the person in question been isolated?

Out of the 9 passengers who detected others with symptoms of COVID-19, only 1 person (11.1%) responded affirmatively in relation to its isolation. There were 4 negative answers (44.4%) and 4 "Don't know" answers (44.4%). It is therefore concluded that these were probably cases of passengers who had previously tested negative for COVID-19.

27.2. Was the symptomatic person's family also isolated?

To this question none of the 9 respondents detected any action by the airline to isolate the family members of the symptomatic, there were 3 answers (33.3%) "NO" and 6 answers "I DON'T KNOW".

27.3. Has any crew member been assigned to service the symptomatic and his family?

Regarding the designation of a specific crew member to serve the needs of the symptomatic person and his/her family, the responses were the same as the previous question, i.e. 0 responses (0%) "YES", 3 responses (33.3%) "NO" and 6 responses (66.7%) "I DON'T KNOW".

27.4. Did you notice anything distinct in the landing?

Here we have unanimity of responses in relation to disembarkation, with the 9 responses obtained being negative (100%). It is concluded that the

disembarkation process occurs identically, regardless of the presence of a symptomatic.

27.5. If yes, could you elaborate further?

N/A

Note: If the answer to 27 is “YES” then, and only then, 27.1., 27.2., 27.3., 27.4 and 27.5 would be questioned.

28. How much time did you waste on each stage of your journey beyond the usual?

28.1. At the airport entrance:

The responses “at the airport entrance” were as follows: 130 responses (69.9%) “Nothing to report”, 25 responses (13.4%) “5 to 10 minutes”, 15 responses (8.1%) “10 to 15 minutes”, 8 responses (4.3%) “15 to 30 minutes”, 6 responses (3.2%) “30 to 60 minutes”, 1 response (0.5%) “60 to 120 minutes” and 1 response (0.5%) “More than 120 minutes”. The data indicate that most passengers did not notice any loss of time in relation to the pre-COVID-19 period. There was also a certain inverse proportionality between the number of responses and the time lost. It is concluded that the temporal impact on passengers was not significant.

28.2 In the check-in area:

The responses "in the check-in area", were as follows: 99 responses (53.2%) “Nothing to report”, 31 responses (16.7%) “5 to 10 minutes”, 15 responses (8.1 %) “10 to 15 minutes”, 24 responses (12.9%) “15 to 30 minutes”, 16 responses (8.6%) “30 to 60 minutes”, 1 response (0.5%) “60 to 120 minutes” and no response (0%) “More than 120 minutes”. About half of the respondents did not notice any difference. However, the results related to effective time losses were higher in the check-in area compared to the airport entrance. Almost half of the respondents speak of an effective impact.

28.3 In the security control area:

The answers “in the security control area”, were as follows: 81 answers (43.5%) “Nothing to report”, 33 answers (17.7%) “5 to 10 minutes”, 32 answers (17.2 %) “10 to 15 minutes”, 29 responses (15.6%) “15 to 30 minutes”, 9 responses (4.8%) “30 to 60 minutes”, 1 response (0.5%) “60 to 120 minutes” and 1 response (0.5%) “More than 120 minutes”. This airport area had a very significant impact on the

day-to-day of passengers. It was the area where the temporal losses were the most significant. More than half of the respondents lost time in this area, with 29 people losing between 15 and 30 minutes and 9 people between 30 and 60 minutes.

28.4 At the departure terminal:

The responses "at the departure terminal" were as follows: 81 responses (52.7%) “Nothing to report”, 23 responses (12.4%) “5 to 10 minutes”, 23 responses (12.4%) “10 to 15 minutes”, 24 responses (12.9%) “15 to 30 minutes”, 15 responses (8.1%) “30 to 60 minutes”, 3 responses (0.5%) “60 to 120 minutes” and 0 responses (0.5%) “More than 120 minutes”. Despite the fact that about half of the respondents did not lose time, the exceptionally high number of responses (15) to the period “30 to 60 minutes” should be noted.

28.5 In the duty-free zone:

The responses "in the duty-free zone" were as follows: 149 responses (80.1%) “Nothing to report”, 18 responses (9.7%) “5 to 10 minutes”, 12 responses (6.5%) “10 to 15 minutes”, 2 answers (1.1%) “15 to 30 minutes”, 3 answers (1.6%) “30 to 60 minutes”, 1 answer (0.5%) “60 to 120 minutes” and 1 answer (0.5%) “More than 120 minutes”. In this airport area, most respondents say they have not noticed any change. It can thus be concluded that it was the area of the airport with the highest number of records where there was no temporal impact on passengers.

28.6 In the boarding area:

The responses "in the departure area" were as follows: 81 responses (43.5%) “Nothing to report”, 25 responses (13.4%) “5 to 10 minutes”, 36 responses (19.4%) “10 to 15 minutes”, 32 responses (17.2%) “15 to 30 minutes”, 10 responses (5.4%) “30 to 60 minutes”, 2 responses (1.1%) “60 to 120 minutes” and 0 responses (0%) “More than 120 minutes”. In this area of the airport, there were indeed temporary losses in relation to the pre-COVID-19 period, although most of these losses were small or reasonable. It is concluded, therefore, that passenger boarding operations suffered effective temporal losses.

28.7 On the plane:

The "on the plane" responses were as follows: 104 responses (43.5%) “Nothing to report”, 20 responses (10.8%) “5 to 10 minutes”, 19 responses (10.2%) “10 15 minutes”, 16 responses (8.6%) “15 to 30 minutes”, 4 responses (2.2%) “30 to 60 minutes”, 6 responses (3.2%) “60 to 120 minutes” and 17 responses (9.1%) “More than 120 minutes”. Despite the fact that more than half of the respondents did not notice increased time losses due to the measures, the excessively high number of responses “60 to 120 minutes” (6) and “More than 120 minutes” (17) should be noted. Thus, time losses are significant.

28.8 In the landing area:

The answers “in the landing area”, were as follows: 107 answers (57.5%) “Nothing to report”, 26 answers (14%) “5 to 10 minutes”, 27 answers (14.5%) “10 to 15 minutes”, 21 responses (11.3%) “15 to 30 minutes”, 4 responses (2.2%) “30 to 60 minutes”, 1 response (0.5%) “60 to 120 minutes” and 0 responses (0%) “More than 120 minutes”. Most respondents answered “Nothing to report”. The few cases whose impact was felt, experienced small temporal losses.

28.9 In the baggage claim area:

The answers “in the baggage reclaim area”, were as follows: 128 answers (68.8%) “Nothing to report”, 5 answers (2.7%) “5 to 10 minutes”, 24 answers (12.9 %) “10 to 15 minutes”, 21 responses (11.3%) “15 to 30 minutes”, 7 responses (3.8%) “30 to 60 minutes”, 1 response (0.5%) “60 to 120 minutes” and 0 responses (0%) “More than 120 minutes”. The data indicate that most passengers did not notice any time loss in relation to the pre-COVID-19 period. Those who did, experienced reasonable wasted time.

28.10 At the arrival terminal:

The responses "at the arrival terminal" were as follows: 108 responses (58.1%) “Nothing to report”, 26 responses (14%) “5 to 10 minutes”, 25 responses (13.4%) “10 15 minutes”, 20 responses (10.8%) “15 to 30 minutes”, 6 responses (3.2%) “30 to 60 minutes”, 1 response (0.5%) “60 to 120 minutes” and 0 responses (0%) “More than 120 minutes”. More than half of the respondents lost no more time

than on their previous trips and those who experienced some loss were small to reasonable.

28.11 At the airport exit:

The responses "on departure from the airport" were as follows: 133 responses (71.5%) “Nothing to report”, 21 responses (11.3%) “5 to 10 minutes”, 15 responses (8.1%) “10 to 15 minutes”, 16 responses (8.6%) “15 to 30 minutes”, 1 response (0.5%) “30 to 60 minutes”, no response (0%) “60 to 120 minutes” and equally no responses (0%) “More than 120 minutes”. Almost three quarters of respondents did not notice any losses in this section of the airport and those who did notice were minor disturbances. It can then be concluded that there was no significant temporal impact on passengers.

4.3 Conclusions

In short and as mentioned in the introduction to this chapter, a series of interviews and surveys were conducted in order to ascertain the manner, homogeneity and effectiveness of measures against COVID-19 at airports.

First, interviews were carried out with specialists in the maintenance and management of airports. Thus, at the same time, several airports were contacted in order to investigate a series of questions. It was found that all those who had contingency plans or contingency plans including measures against infectious diseases under the 'health emergency' section remained rather vague, with overly simplistic plans in place to deal with the SARS-Cov-2 derived pandemic crisis. In the Portuguese case there were no pre-established contingency plans, so the IROPS plan was developed to create the necessary mechanisms and procedures. It should be noted that these plans were under the jurisdiction of regulatory bodies that normally belong to the state. In the specific case of the USA, certain airports were under the jurisdiction of the respective states or even the country. In the case of COVID-19, and when implementing the measures, there was a joint effort between several regulatory bodies, these being the government and the airport itself.

The measures implemented have changed over time, depending on the evolution of the pandemic (sharp variations in the number of infections and deaths) and the emergence of new, more efficient technologies. The most explicit example was the obligation to have a vaccination certificate for air travel as soon as vaccines appeared and were made available to the general population. The measures implemented were vast, but the most

efficient were the mandatory use of masks, social distancing, disinfection of surfaces and the presentation of a negative PCR test or vaccination certificate. Similarly, some measures proved to be relatively low cost-effective, leading to their abolition, such as disinfection of passenger luggage or temperature checkpoints. The concept of "layered mitigation" measures is also believed to have been successful in significantly reducing the risks of contagion in air travel. Although not all airports have implemented identical measures, over time there has been some unification of measures.

On an economic level, large losses were incurred throughout the sector due to the inability to travel. However, not all branches of aviation were equally affected. There was less impact on domestic aviation compared to international one and a greater impact on passenger versus cargo aviation. A faster recovery in the domestic passenger and cargo transit sectors can therefore be expected. It is believed that pre-COVID-19 levels will be recovered between 2024 and 2025 for the aviation industry as a whole.

With regard to the surveys, 186 valid responses were recorded out of the 300 responses submitted (only people who had actually travelled by air in 2021 were considered as valid responses). In general, a wide implementation of the measures against COVID-19 was noted across the 90+ airports indicated. A certain decrease in the concern of airports to ensure measures such as social distancing throughout the passenger journey was also identified. At the level of disinfection of the areas and in relation to the pre-COVID-19 period, no significant increase in the frequency of cleaning of the areas was recorded. One of the reasons for this may be that the most thorough cleaning is usually scheduled for off-peak periods, so as to have the least possible impact on the flow of passengers. The most implemented measures were the use of masks (97.8%) and the existence of alcohol gel dispensers for free use by passengers. The least usual were the disinfection of luggage (3.2%) and the existence of toilets dedicated to crew members (5.4%).

It is also noteworthy that none of the 186 interviewees presented fever in the temperature controls normally performed at the beginning of the trip, which shows the inefficiency of this method. In the same way, it was not possible to infer how a possible positive case of SARS-Cov-2 was processed, due to the inexistence of cases with temperatures above the stipulated one. Another interesting piece of data, on the negative side, is related with the appearance of new contactless procedures, as 81.2% of those questioned revealed that they had not noticed any alteration to existing procedures, which shows a certain lack of interest on the part of the airport entity in the implementation of new technologies. Even so, new procedures were registered, such as automatic validation of boarding passes, electronic payments, automatic collection of baggage and procedures using the internet.

Vaccination certificates or negative PCR were widely requested by airlines and airport staff. There was also a certain concern on the part of the airlines to ensure the orderly movement of passengers at both boarding and disembarkation processes, although with special emphasis on boarding. Although somewhat rare, cases of people with symptoms of COVID-19 were detected by the respondents. Unfortunately, it was not possible to make inferences about the airlines' procedures in this situation as almost all answers to subsequent questions were "NO" or "I DON'T KNOW".

As for the time losses recorded by passengers at each stage of their journey, when compared to the pre-COVID-19 period, the area of the airport where they were most felt was in the security control area. On the other hand, the area where there was the least time disruption was in the duty-free zone. Significant losses were also recorded in the check-in area and inside the aircraft. Otherwise, no significant losses were experienced in relation to the pre-pandemic period. We can thus conclude that the measures implemented did not have a very significant impact on the major part of the passenger journey.

Chapter 5 – Conclusions

5.1 Dissertation Synthesis

Entities, such as airports, have emergency and contingency plans whose objective is to minimise the impact of a given disruption, both at operational and monetary level. These plans are fundamental in preparing the airport to deal with unexpected situations that could put lives at risk or cause potential damage to property. It should be noted that an efficient contingency plan is a plan capable of controlling or mitigating a given occurrence, in order to ensure the daily operations of the airport and return it to "normality", with the available resources and in the shortest possible time. Furthermore, adequate planning will have the advantage of inspiring confidence in the final consumer, i.e. the passenger, to prioritise air transport over alternative means of transport.

There have been numerous occurrences that have negatively impacted the aeronautical sector, both on a small and large scale. During this dissertation, in the "State of the Art", the major disruptions experienced to date were highlighted, namely, the 9/11 attacks in the United States, the SARS epidemic with epicentre in China, the Eyjafjallajökull eruption in Iceland and finally the MERS epidemic, which mainly affected the Middle East. This historical contextualization came about in order to introduce COVID-19, as being the greatest air traffic disruption ever experienced. In the face of these disruptions, changes to contingency plans were observed, which proves that there are no perfect plans and that there is always room for improvement. In the specific case of MERS-CoV, an acceleration in the implementation of preventive measures was observed, based on the lessons learned from SARS-CoV in 2003.

In late 2019 a "viral pneumonia of unknown cause" broke out, in Wuhan province of China, which would later be identified as "COVID-19" and whose virus derived from "SARS-CoV-2". It quickly spread worldwide, with cases in almost every country. Given its great transmissibility and the possibility of asymptomatic carriers of the virus, the number of infections and deaths exploded, leading to the collapse of a large number of health systems. This high incidence led governments to declare restrictive measures such as confinements and border closures. These measures were especially harmful to both the tourism and aviation sectors, given the close relationship between them. Huge and unprecedented losses were recorded, not only at operational level (drastic reduction in the number of flights) but also at economic level (significant decrease in revenues). In order to guarantee tickets in the first months of the pandemic, many airlines adapted to cargo transport, taking advantage of the exponential growth of the online market, caused

by the closure of physical shops. With the advent of vaccines, the foundations were laid for a return to "normality" and a recovery to pre-pandemic levels.

Two studies were carried out in order to infer the capacity of airports and their contingency plans to manage the pandemic crisis of COVID-19. Thus, interviews were conducted with experts in the field of airport management, as well as surveys of passengers who had travelled by plane in the year 2021.

Following the interviews, some clear conclusions emerged. It was found that although there were already sections in the airport contingency plans with "health emergencies", these were vague and very inefficient to deal with a pandemic crisis such as the one that emerged in early 2020. Other countries, such as Portugal, did not have a contingency plan in place to deal with COVID-19 and so IROPS emerged. Therefore, the responsible regulatory authorities, together with other bodies, such as the ministry of health or the airport, have been updating these plans, depending on the evolution of the pandemic and the emergence of more efficient technologies, such as the vaccination certificate, for the detection of potential positive cases to SARS-CoV-2. Likewise, some of the measures adopted, proved to be not very cost-efficient, which led airports to abolish them. The most common cases were temperature control points and disinfection of luggage. It was then concluded that detection of virus carriers was only possible through "layered mitigation", as no single measure alone proved to be effective enough.

Economically speaking, COVID-19 led to the greatest disruption of air traffic in history, reaching unprecedented losses. Within the aviation sector there was a greater impact on passenger transport relative to cargo, as well as a greater impact on the domestic market compared to the international one. It is therefore expected that the least affected sectors will be the first to recover, with forecasts for 2024-2025 for the aviation industry as a whole.

Similarly, some conclusions were reached when analysing the data collected from the surveys. Thus, 300 answers were registered, of which only 186 were considered valid (people who actually travelled by plane in 2021). Generally speaking, in the 90+ airports where the surveyed passengers flew, a wide implementation of measures to combat the spread of SARS-CoV-2 was observed. In fact, there were measures greatly implemented and adopted by passengers such as the mandatory use of masks (97.8%) and use of alcohol gel dispensers. However, in these surveys there were also poorly implemented and less efficient measures, such as disinfection of luggage (3.2%), and the existence of bathrooms dedicated to crew members (5.4%).

Regarding the temperature checkpoints and taking into account that none of the 186 questioned presented fever, we conclude that this method turned out to be very inefficient, justifying its abolition (as seen in the interviews). Due to this situation, it was not possible to infer how airports would act when detecting a potential SAR-CoV-2 positive case. Presentation of the vaccination certificate or negative PCR, as well as social distancing were two measures widely adopted by airports and air carriers. Finally, it was observed that the implementation of measures did not interfere too much with passenger transit time.

5.2 Concluding Remarks

In the course of this work, many answers were obtained to the questions raised in the first chapter. It was seen that although contingency plans existed in all the airports addressed and that these plans covered issues such as "health emergencies", they showed a lack of detail and depth when implemented. Thus, adjustments were necessary for greater efficiency. These adjustments were not only derived from the shortcomings present in the pre-COVID-19 contingency plans, but also from the changing nature of the pandemic or the emergence of new technologies.

Through interviews and surveys, it was found that, for the most part, practice corresponded to theory, and the previously stipulated measures actually took place during the passengers' travels (information obtained using the surveys). Another of the issues raised, was the possibility of cultural and geographical differences between airports influencing the measures implemented. Although a certain homogeneity has been noted in the measures implemented, especially during the evolution of the pandemic, the lack of answers from experts at some airports made this understanding difficult. Furthermore, the answers obtained were essentially in the American continent, with no great point of comparison with the rest of the world.

At the economic level, it was not possible to obtain the cost figures for the implementation of the measures, as none of the experts interviewed were in possession of this information or were restricted by confidentiality policies. Even so, it was possible to identify the most efficient measures as well as those that were too expensive in relation to their efficiency. Examples of this are the use of masks and social distancing as more cost-effective measures and temperature control points as a measure that has been abolished over time.

5.3 Prospects for Future Work

During the course of this work, some limitations were found, especially in relation to interviews and surveys and the difficulty in obtaining answers from all over the world. Thus, the prospects for future work are as follows:

- Expand the interviews to cover all continents in order to verify whether cultural and geographical differences influenced the measures implemented in the world.
- Include small airports or even airfields that may have closed during the pandemic crisis or in the first months of confinement, in order to verify whether their strategy would be maintained or not in the event of a new crisis.
- Conduct interviews with air carriers in order to include their vision in the measures implemented against COVID-19.
- Taking into account the author's nationality and his network of contacts, most of the respondents travelled on the European continent. Another future work perspective would be to expand the survey to all continents, to verify the homogeneity or not of the opinions and sensations experienced, regardless of the places of departure and arrival.
- At the end of the pandemic, verify the total economic impact, as well as compliance with the economic recovery prospects for 2025.
- In the event of a new pandemic crisis in addition to COVID-19, check whether the implementation of new measures will be done more quickly and effectively. Also verify that the contingency plans, at that time, will be properly prepared to deal with the disruption without the need to implement alternative measures.

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Appendix A – Article Submitted to Journal of Airline Airport Management (JAIRM)

Airports and Emergency Planning: Measures Implemented to Prevent the Spread of COVID-19 and their Effectiveness

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Abstract

Purpose: The aim of this paper is to analyse the measures implemented to prevent the spread of COVID-19 and their effectiveness at airports around the globe. The study aims to identify whether airports were prepared, through their emergency and contingency plans, to deal with this pandemic situation.

Methodology: The study starts by reviewing the state of art regarding the notions of Emergency planning and a chronological analysis of past disruptions. After that, a brief introduction to COVID-19 will be given and some findings from the expert interviews and passenger surveys previously conducted will also be presented.

Findings: Airports were not prepared to deal with a pandemic situation like COVID-19. As the pandemic developed, measures and processes were put in place. Some proved to be very effective, such as the mandatory use of masks, and others were not very cost-effective, such as temperature checkpoints. It was also found that passengers did not suffer much loss of time when travelling due to the measures put in place.

Research limitations: The lack of responses in the interviews made it almost impossible to analyze whether the culture of the countries and the geographical location of the airports had any influence on the measures implemented to prevent COVID-19.

Originality/Value: Comprehensive review of the implemented measures, as well as the corresponding challenges from the passenger's point of view.

Keywords: Emergency Planning; Airport Emergency Planning; COVID-19; Disruptions; Economic Impact; Implemented Measures.