Preparing for the Next Pandemic

A Case Study of COVID-19 in Taiwan

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Abstract

At the end of 2019, the outbreak of COVID-19 in Wuhan swiftly spread globally and led to a pandemic. Many countries still suffer under this outbreak and have failed to keep their COVID-19 infection numbers low. Although many countries have implemented measures to fight the spread of the virus, many of these techniques have not seemed to work. Many countries appear to be helpless in the fight against COVID-19. Conversely, Taiwan has fared comparably well throughout the pandemic, and the nation's infection numbers have been consistently low.

Several studies have conducted a significant amount of research in many fields in the two years since the outbreak; however, these studies often employed a small number of factors that were typically from one field, leading to a lack of knowledge and an incorrect image of reality. This paper aims to create a deeper understanding of factors that influence the spread of the virus based on a case study of Taiwan to understand how the nation has kept a minimal infection rate. Through an in-depth descriptive analysis, the gathered scientific research and semi-structured interviews are analysed to obtain a deeper understanding of the nation's success.

This research concludes that sociocultural factors and implemented policies are the primary elements in Taiwan's positive situation; additionally, meteorological factors benefit the island and must be acknowledged.

Ultimately, these results can enable other countries to seize control of the current pandemic and prepare for the next, which may arrive sooner than expected.

Acknowledgments

I want to express my gratitude to the University of Agder for offering the opportunity to learn and shape my thought process to better understand the world. Moreover, I would like to thank the University of Agder for providing the academic knowledge that will shape my future and enable me to conduct research.

I am grateful to be able to conduct interdisciplinary research, since this is one of my passions and, in my view, is needed now more than ever before to understand our modern and often confusing world in a deeper and clearer way. In particular, the combination of natural and social sciences seems necessary. Moreover, since two of my dominant passions are biology and medicine, I sincerely appreciate the chance to include knowledge from these fields in this thesis, and I anticipate this continued combination in my professional future.

Furthermore, I would like to express my gratitude toward my supervisor, M.Sc. D.Phil. Oxon Christian Webersik, from the faculty of development management at the University of Agder, who has supported me through my research journey.

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Finally, I would like to express my gratitude toward everyone who contributed to my thesis.

Abbreviations

AH- absolute humidity

CFR- Case Fatality Rate

CO- carbon monoxide

IAMAT- International Association for Medical Assistance to Travelers

MERS- Middle East respiratory syndrome

MOHW- Ministry of Health and Welfare

MRT- Mass Rapid Transit

NHI- National Health Insurance (NHI)

NO- Nitrogen

NO_2- Nitrogen dioxide

NPIs- Nonpharmaceutical Interventions

OECD- Organization for Economic Co-operation and Development

PM- Particulate Matter

PPE- Personal Protective Equipment

RH- Relative Humidity

SARS- Severe Acute Respiratory Syndrome

SO- Sulfur

WHO- World Health Organization

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Chapter One: Introduction

1.1) Background

Infectious diseases have cost millions of lives throughout human history and have produced economic chaos as well as political and social unrest (Commission On Global Health Risk, 2016). In the past few decades, the world has witnessed the emergence of numerous extensive outbreaks of infectious diseases, including "Ebola, severe acute respiratory syndrome (SARS), hantavirus, human immunodeficiency virus (HIV), and novel strains of influenza" (National Academy of Medicine, Secretariat & Commission on a Global Health Risk Framework for the Future, 2016, p. v). These outbreaks are increasing because of the growing world population, which leads to a higher demand for food. This increases animal-human interaction, which can lead to diseases being transmitted from animals to humans (Commission On Global Health Risk, 2016). Additionally, globalisation and environmental destruction have led to an increased frequency of infectious diseases as a threat to global security (Commission On Global Health Risk, 2016). There are gaps in science in the field of pandemic prevention and preparedness; however, other priorities receive more attention, which leads to weaknesses and holes in the preparedness and response strategies (Commission On Global Health Risk, 2016), which are often seen when an epidemic or pandemic arises (Commission On Global Health Risk, 2016). Only a fraction of national security resources are spent to prepare for and prevent pandemics (Commission On Global Health Risk, 2016).

COVID-19 was discovered on 26 December 2019 in Wuhan, China (Hsu et al., 2020a). With its global mortality rate of 5.95%, the disease spread rapidly to every continent except Antarctica and caused a global pandemic (Hsu et al., 2020a; UNDP, 2020). The virus "can live in the air for a long time, and infected individuals with and without symptoms can both spread the disease", which can lead to damages of the "pulmonary alveoli, leading to respiratory failure and death in severe cases" (Hsu et al., 2020a, p. 1). Knowledge about this infectious disease is minimal (Commission On Global Health Risk, 2016); this, combined with nations' minimal funding and research to prevent and prepare for such an outbreak, meant that no state was completely prepared for a pandemic (Nuzzo, 2020, as cited in Spiegel, 2020).

However, Taiwan quickly controlled the virus (Yang & Huang, 2020). Taiwan's experience with the SARS outbreak in addition to other factors may have controlled the spread of the virus. The lack of preparedness in many countries makes it necessary to understand what is helpful in the fight against COVID-19 to control the virus more quickly and to prevent and prepare for the next pandemic. Given the global changes mentioned earlier, the chances of another pandemic are continually increasing; therefore, learning from the Taiwanese response to the COVID-19 pandemic is essential to avoid the next pandemic being as destructive or worse than COVID-19.

1.2) Research Problem

The end of 2019 witnessed the COVID-19 outbreak produced by the SARS-CoV-2 virus. The majority of countries were unprepared for such a pandemic and were profoundly affected; many still face problems in controlling the virus. The majority of countries implemented measures to fight the virus; however, it seems that they have been largely unsuccessful. In many countries globally, colder seasons are approaching, increasing infection numbers are being witnessed, and many governments do not have the means or knowledge to reduce or stop the spread of the virus.

Examining the current COVID-19 pandemic reveals that Taiwan is successfully addressing the COVID-19 outbreak. Taiwan has few new infections and an overall low infection rate. To discover a way to keep the infection rate low, it is necessary to analyse Taiwan's strategy in the pandemic and determine which factors affect the spread of SARS-CoV-2. Ultimately, this analysis is essential for future preparedness to better understand the spread of airborne diseases and appropriate reactions in such situations.

1.3) Research Objectives

1. Develop a logical framework with which to analyse Taiwan
2. Find factors from all possible fields that influence the spread of SARS-CoV-2
3. Investigate through scientific literature how these factors affect the spread of SARS-CoV-2
4. Find data about these factors in Taiwan
5. Analyse this data about the chosen factors in Taiwan
6. Find interviewees and arrange interviews
7. Obtain interviewees' written or verbal consent
8. Interview Taiwanese citizens
9. Examine whether the interview results support the literature
10. Examine which COVID-19 nonpharmaceutical interventions (NPIs) were implemented in Taiwan
11. Analyse which NPIs were key in the fight against COVID-19
12. Propose recommendations on what can be learnt from this case study for other governments and scientific research

1.4) Research Questions

- What is the impact of socio-demographic factors on the spread of SARS-CoV-2 in Taiwan?
- What is the impact of meteorological factors on the spread of SARS-CoV-2 in Taiwan?
- What is the role of sociocultural factors on the spread of SARS-CoV-2 in Taiwan?
- What is the impact of the implemented nonpharmaceutical interventions on the spread of SARS-CoV-2 in Taiwan?
- What can be learnt by Taiwan's COVID-19 response for future preparedness?

1.5) Thesis Statement

Taiwan has been successful in keeping the COVID-19 case numbers low. To better understand the spread of the SARS-CoV-2 virus, analysing socio-demographic, meteorological, and sociocultural factors as well as pol NPIs is necessary to determine which role these factors had in Taiwan. From Taiwan's strategy, other countries can learn how to act quickly, implement suitable measures, and encourage trust between the population and the government.

1.6) Geographic Study Area and Context

Taiwan is one of the most densely populated islands worldwide (World Population Review, 2020). Often, grandparents, parents, and children live in one household (Yang, 2020).

Taiwan's climate is described as hot and humid, but there are differences between the regions in Taiwan (Weather Atlas, n.d.; Hsu et al., 2020b): 50% of the land in Taiwan is in a tropical zone, and the other 50% is in a non-tropical zone (Hsu et al., 2020b). This means that the 15 cities and counties in the non-tropical part of Taiwan have a lower temperature than the seven cities and counties in the tropical part (Hsu et al., 2020b). Tropical zones are characterised by "high temperatures throughout the year (i.e. with no marked 'winter' season), generally high humidity, and high precipitation, although the latter may occur in a distinct rainy season" (Oxford Dictionary of Weather, 2008). The island lies next to the Asian continent, and the Pacific Ocean as well as the Tropic of Cancer provide the island's division into its two climates (The Climate of Taiwan, 2001). Its air pollution is seen as 'moderately unsafe' (IAMAT, 2002).

Taiwan is one of the four Asian dragons, that in less than four decades rapidly industrialized and showed high economic growth rates (Vogel, 1991). The economy in Taiwan proliferated, and the country changed from being primarily agricultural to being a producer of inexpensive products to being a specialist in specific electronic goods (Vogel, 1991). Accordingly, the educational level of the Taiwanese population rose (Solomon, 1999; Vogel, 1991). The private financial investments of the Taiwanese people, their engagement over generations in the process of industrialisation, their long-term sacrifices, and their eagerness to learn in addition to financial aid from the US and the expertise gained from Japan, China, and the US have led Taiwan to where it is today (Vogel, 1991): a country with a robust technological industry and infrastructure similar to the West, a highly educated population, and a sufficient, affordable health care system (Vogel, 1991).

Scholars predicted that during the current pandemic, Taiwan would “have the second-highest "importation risk" of any country” (Chen, 2020) because of the permanent travel between Taiwan and China (Chen, 2020). Nevertheless, only 593 cases of SARS-CoV-2 infections were confirmed by 14 November 2020 (Taiwan Centers for Disease Control, 2020). Compared to other countries, the infection rate in Taiwan has been meagre (Johns Hopkins University, 2020). Prevention, protection, and treatment are essential to turn a pandemic or epidemic into a success story. Taiwan has focussed mainly on the first two points: prevention and protection (Yen, 2020). Measures for disease prevention include “border control; regulation on social gathering; quarantine policy; [and] mask-wearing policy” (Yen, 2020, p. 459), while preventive measures include “the screening of incoming travellers; quarantine policy; testing policy, [and] contact tracing” (Yen, 2020, p. 459).

1.7) Thesis Outline

Chapter One

Chapter one consists of the conceptual background, research problem, research objectives, research questions, thesis statement, thesis structure (this section), and geographic study area and context. This chapter includes why this topic was chosen and its importance in research.

Chapter Two

Furthermore, the theoretical framework offers theories on which this research is grounded. This chapter includes the literature review (which presents current scientific literature and views regarding which factors influence the spread of the SARS-CoV-2 virus), the existing data about research and the existing research gap that must be approached.

Chapter Three

Chapter three focusses on the methodology of the paper, which includes research theory, epistemological and ontological considerations, research strategy, research design, data collection and analysis methods, and whether as well as why this research is reliable and valid. Furthermore, Chapter 3 includes the risks posed by the research, how to address these, and the ethical considerations of the researcher.

Chapter Four

In Chapter four, the factors summarised in Chapter two and the results of the semi-structured interviews are combined with scientific literature to analyse the specific socio-demographic, meteorological, and sociocultural influences as well as implemented NPIs in Taiwan.

Chapter Five

Chapter five discusses the analysis and findings of the socio-demographic, meteorological, and sociocultural factors as well as implemented NPIs in Taiwan; their efficiency and how they interact with each other; and what can be learnt from Taiwan's example for future preparedness.

Chapter Six

This chapter discusses the research results and their meanings, summarises and reflects on the research, and offers the limitations of the research as well as suggestions for future research.

Chapter Two: Theoretical Framework & Literature Review

This chapter will describe the current stand of scientific knowledge on the topic, the research gap that will be investigated as well as the theoretical framework that will be used to analyse it.

2.1) Theoretical Framework

The majority of research papers regarding COVID-19 or SARS-CoV-2 analyse only one field and exclude all other fields, which creates a lack of knowledge and understanding that is necessary to fight this pandemic. For example, during the Ebola outbreak, it was necessary to understand the medical and biological factors as well as the sociocultural factors to successfully contain the virus (Whembolua et al., 2015). Consequently, in this paper, several fields are combined and therefore create a more holistic picture about the spread of COVID-19. This holistic view enables further understanding of the disease and simplifies the containment of the virus. Hence, data regarding several COVID-19 NPIs implemented in Taiwan are collected and sorted to understand the actions that maintained a low infection rate.

Additionally, research literature regarding NPIs as well as meteorological, sociocultural, and socio-demographic factors that influence the spread of SARS-CoV-2 are collected and contextualised within Taiwan and its population to understand the ease or difficulty of SARS-CoV-2's spread in Taiwan. Furthermore, health workers and citizens are interviewed to confirm the gathered data. Thus, a holistic picture of the spread of SARS-CoV-2 in Taiwan is created.

The multifactorial or multicausal theory of disease causation is utilised (Hewa, 2016; Furman, 2020). This theory indicates that although modern medicine and laboratory science have significantly impacted the decline of mortality, the process of disease causation is far more complex than the one factor alone explained by the germ theory (Hewa, 2016) or the monocausal theory of disease (Furman, 2020).

The monocausal theory states that the reason for diseases is single microbial (Fuhrman, 2020; Ross, 2018). This causal relationship between disease and microbial offers sufficient reasoning to explain why infections occur and how to predict their occurrence (Broadbent, 2013, as cited in Copeland, 2016). Dubo (1959) states that the monocausal theory is significant restraint through its oversimplification (Dubos 1959, as cited in Ross, 2018) while Copeland (2016) even argues that the monocausal approach can result in harm: “research can be inappropriately narrowed in scope, researchers and funding misdirected away from other equally valuable investigations, and mistaken beliefs can harm patients in the value of treatment options” (Copeland, 2016, p. 1055). The majority of interpretations of the germ theory use the monocausal theory, claiming that all germ theory argues that there is only one single cause for a disease (Cockerham and Richey 1997, p. 35, as cited in Ross, 2018, p. 8) and that if this cause is found the disease becomes controllable (Agar 1994, p. 394, as cited in Ross, 2018, p. 8). The germ-theory states that the single cause of an infection can be explained by contagions like bacteria (Ross, 2018). Like the monocausal theory also the germ theory shows substantial limitations (Ross, 2018).

The multicausal theory includes several factors related to the disease's aetiology (Furman, 2020), recognising the interaction and contribution of the disease through several factors (Najman, 1980; Hewa, 2016; Broadbent, 2009), such as the physical and social environments (Hewa, 2009; Najman, 1980), which include socioeconomic and behavioural variables (Furman, 2020; Hewa, 2016). This supports the quote from Leave and Clark (1965), “The complex process of deviation from health is the result of continuous chains of cause and effects, not of single or specific causes alone” (Leave & Clark, 1965, as cited in Najman, 1980, p. 232). Each factor must be understood in a 'web of causation' (MacMahon & Pugh, 1970, as cited in Broadbent, 2009) to holistically fight the disease (Hewa, 2016) because one's environment has the potential to strengthen or weaken the host through societal activities (Hewa, 2016). Broadbent (2009) argues that the majority of medical conditions on which the epidemiological field naturally focusses demand employing the multifactorial theory because of the complexity of most diseases.

2.2) Literature Review

In this chapter, the current scientific literature regarding factors that influence the SARS-CoV-2 virus are discussed. This literature provides an important background to answer the research questions. This chapter offers the reader an understanding of why socio-demographic, meteorological and sociocultural factors as well as NPIs are relevant in the context of studying the spread of COVID-19. These variables are explained in a short but detailed overview with necessary subchapters to demonstrate which factors fall under the categories mentioned above. Significant amounts of research have been conducted regarding how the virus spreads based on analysis in one or two fields; however, no research to date has considered the creation of a holistic approach to understand the spread of the virus.

In this chapter several factors will be analysed to understand which ones may contribute to the spread of SARS-CoV-2 how they in detail do that. This investigation will be later used to analyse which factors play a role in the spread of SARS-CoV-2 in Taiwan.

2.2.1) Socio-Demographic Factors and Medical Care

a) Population Density

Some studies have indicated statistical significance in the morbidity and mortality rates of SARS-CoV-2 that are connected to population density, meaning that cities with higher population densities exhibit a higher percentage of SARS-CoV-2 infections and COVID-19-related deaths (Kodera et al., 2020; Kadi & Khelfaoui, 2020). Scientists suggest that SARS-CoV-2 tends to spread via close interactions among people; hence, there may be an alarming surge in COVID-19 cases in countries with high population densities (Garland et al., 2020). Overall, this places individuals who reside in densely populated regions, such as metropolitan areas or large cities, at risk since they have a higher probability of human-to-human contact (Bhadra et al., 2020).

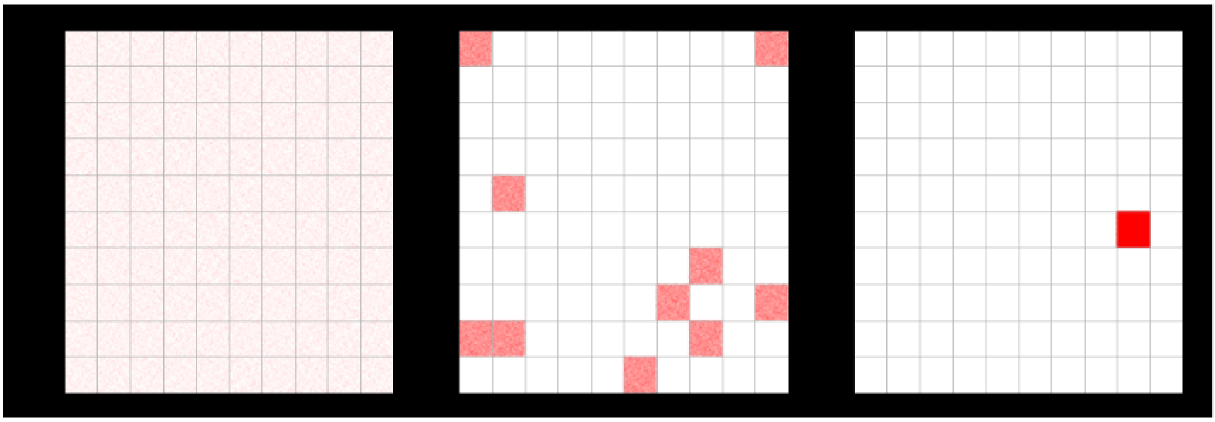
The World Health Organization (WHO) recommends maintaining a distance of more than one metre between oneself and those who are sneezing or coughing. However, following this recommendation is challenging in areas with high population densities (WHO, 2020, as cited in Rocklöv & Sjödin, 2020).

Ultimately, a high population density means that people in public places are near each other, thus increasing the chances of spreading the virus (Kadi & Khelfaoui, 2020). India is one of the most significant examples of a densely populated country; people here are constantly confined to small areas in trains, public vehicles, and ration queues as well as in the streets and other places (Bhadra et al., 2020). Consequently, the pandemic had a significant impact here, as well as in São Paulo in Brazil, New York in the US, Madrid in Spain, North Rhine-Westphalia in Germany, and the Lombardy region in Italy as well as other heavily populated places (Copiello & Grillenzoni, 2020).

However, some studies have demonstrated that there is no correlation between the infection rate of SARS-CoV-2 and the population density (Kodera et al., 2020). This may be explained by several factors. For example, it may be due to the method utilised to measure the population density in a particular area or because some measures were appropriately executed to diminish the effect of population density (Kodera et al., 2020). However, it remains true that some countries that strictly implemented lockdowns did not indicate a significant association between population density and infection rates (Kodera et al., 2020).

The following figure displays the methodological problem of population density as a factor.

Figure 1: Population Density



(Garland et al., 2020.)

Example:

Assume three countries are within an area of 100 km^2, and each has a population of 100,000. Consider the population of each kilometre grid square (Garland et al., 2020), as demonstrated in the following:

- In Averagia, the population is uniformly spread (left-hand figure). Each grid square has 1,000 residents (Garland et al., 2020).

- Builtupia has 10 towns, each with 10,000 people residing in a single square kilometre (middle figure). The remaining land is uninhabited (Garland et al., 2020).

- Citia has only one city, and approximately 100,000 people reside in a single square kilometre (right-hand figure). The remaining land is again considered uninhabited (Garland et al., 2020).

Each country in this example has a standard population density that is simply 100,000/100 = 1,000 people per square kilometre; thus, it may be naive to conclude that the nations are equally crowded (Garland et al., 2020). Citia remains more crowded than Builtupia (Garland et al., 2020). However, comparing Builtupia and Averagia reveals that Builtupia is more crowded than Averagia (Garland et al., 2020). Therefore, one can see that if COVID-19 spreads, then it would spready more rapidly in Citia than in Builtupia, and Builtupia would ultimately experience a faster spread of COVID-19 than Averagia (Garland et al., 2020).

Additionally, in regions with high population densities where the wind tends to blow at approximately 30 km/h or more, the chances of transmission and spread of the SARS-CoV-2 virus increase drastically (Coşkun et al., 2020). Research has illustrated that wind speed and population density are significant in spreading the virus (Coşkun et al., 2020). In fact, approximately 94% of SARS-CoV-2 infections are explained through these factors (Coşkun et al., 2020).

b) Crowding

Crowding may increase the risk of extended outbreaks (Rader et al., 2020). To analyse the parameters of SARS-CoV-2, it is important to differentiate between crowding and population density (Hamidi & Hamidi, 2021). According to Hamidi and Hamidi (2021), crowding is a significant factor in increased infection rates (Hamidi & Hamidi, 2021). The researchers also indicate that one of the significant crowding-related variables is the average size of each household (Hamidi & Hamidi, 2021). In their study, they highlight the differences between population density and different types of crowding, claiming that the number of crowded households, based on the household size, is strongly related to a high per-capita morbidity rate (Hamidi & Hamidi, 2021).

Studies have revealed that greater social exposure as a result of work and household crowding has been significant in spreading the disease throughout the pandemic (Almagro et al., 2021). Additionally, residents of lower socioeconomic neighbourhoods live in more crowded households (Riou et al., 2021; Joseph Rowntree Foundation, 2020; Cardosa et al., 2020, as cited in Patel et al., 2020). Generally, household overcrowding is strongly associated with an increased number of COVID-19 cases (Almagro et al., 2021). In many cases, people living in poor conditions experience difficulty maintaining social distancing, and they often have reduced access to outdoor spaces (US Bureau of Labor Statistics, 2019, as cited in Patel et al., 2020).

Touristic attractions may also indirectly impact the spread of viruses in other parts of a city and are a reason for the increased per-capita infection rate in their surrounding areas (Hamidi & Hamidi, 2021). After the first wave of the virus, cities with higher levels of crowding were found to exhibit increased infection rates and longer durations of the pandemic (Rader et al., 2020).

c) Age Distribution

Age is a significant factor in the severity of infection, morbidity, and mortality of patients with COVID-19 (Dong et al., 2019; Zhou et al., 2020; Ricardo et al., 2020, as cited in Davies et al., 2020; Bi et al., 2020, as cited in Davies et al., 2020; Baud et al., 2020, as cited in Cortis, 2020; Dong et al., 2019; Zhao et al., 2020, as cited in Davies et al., 2020; Pequeno et al., 2020). Additionally, it has been established that the age structure ("distribution of people of various ages") (ThoughtCo, 2019) has a significant role in the spread of the SARS-CoV-2 virus (Dudel et al., 2020).

Several case reports have explained the increased probability of clinical symptoms due to advanced age, thus demonstrating age-dependent severity (Dong et al., 2019; Zhou et al., 2020; Ricardo et al., 2020, as cited in Davies et al., 2020). Notably, the chances of presenting clinical symptoms seem to be related to age, with older patients often exhibiting symptoms more frequently than younger patients, although the younger patients are also infected (van Kerckhove et al., 2013, as cited in Davies et al., 2020). This age disparity means that children, compared to adults, have a lower tendency to feature clinical symptoms, lower vulnerability to infections, or both (Davies et al., 2020). However, children can still transmit the virus to other individuals, although this occurs at a lower rate than for adults which are fully symptomatic (van Kerckhove et al., 2013, as cited in Davies et al., 2020).

Generally, the low infection rates observed in low- and middle-income countries are due to their populations being younger than those of other countries. Conversely, Italy experienced a high case fatality rate (CFR), which can be explained by the increased number of older patients (Henriques, 2020; Onder et al., 2020, as cited in Sudharsanan et al., 2020). Several reports have verified that the virus is transmitted through asymptomatic carriers (Liu et al., 2020; Rothe et al., 2020, as cited in Kronbichler et al., 2020). This suggests that younger individuals who usually have mild symptoms or are asymptomatic may be critical in spreading the virus (Guan et al., 2020, as cited in Kronbichler et al., 2020). These young people are often statistically undetected, as they do not seek medical assistance because they are asymptomatic or only experience mild symptoms (Dudel et al., 2020; Kronbichler et al., 2020).

Furthermore, variations in the contact patterns among people of different ages are significant in the infection rate of SARS-CoV-2 (Davies et al., 2020). For example, compared to adults, children are more likely to develop more social contacts, and thus their behaviour may be a greater contributor to the transmission of the virus (Mossong et al., 2008; Cauchemez et al., 2008; Eames et al., 2012, as cited in Davies et al., 2020; Kronbichler et al., 2020). Those between 20 and 29 years of age usually contribute to the spread of SARS-CoV-2, as they are more socially active and form a major part of the working community who travel frequently (Kronbichler et al., 2020). A Japanese study concludes that asymptomatic and undocumented infected patients are the major source of transmission of COVID-19 (Kronbichler et al., 2020).

Statistically, COVID-19 cases have been more frequent and more severe in areas with larger proportions of older people. However, if the majority of the population consists of younger people, then deaths resulting from COVID-19 would be lower (Baud et al., 2020, as cited in Cortis, 2020; Davies et al., 2020; Esteve et al., 2020).

If a country with a large percentage of older people does not take effective control measures, then it may experience a high morbidity rate, especially during the later stages of the pandemic, due to a high amount of symptomatic cases (Davies et al., 2020). Thus, it can be concluded that the age structure is a significant factor in the COVID-19 pandemic and that age composition is essential for explaining the variations in CFRs (Onder et al., 2020; Lazzerini & Putoto, 2020; Bignamo & Ghio, 2020; Dowd et al., 2020; Kashnitsky & Aburto, 1995, as cited in Dudel et al., 2021; Dowd et al., 2020a, p. 9696).

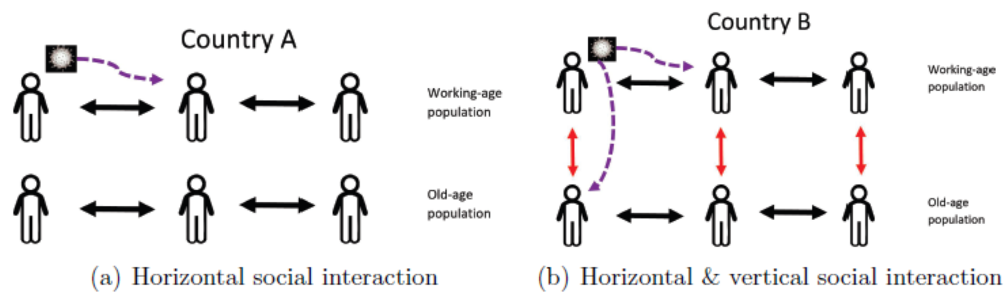
d) Intergenerational Living

Generally, intergenerational contact increases the rate of infection, as younger people tend to infect the elderly (Dowd et al., 2020a). Intergenerational living has also been associated with a significant increase in the number of COVID-19-related deaths (Fenoll & Grossbard, 2020). Caregiving, intergenerational relationships, and family structure have a potential impact on exposure to SARS-CoV-2 (Stokes et al., 2020), as multigenerational families comprising individuals of different ages who share resources and provide care are more likely to spread COVID-19 (Dowd et al., 2020, as cited in Stokes et al., 2020). Adults in these situations, especially women, often care for their children and older parents and are concurrently employed (Stokes et al., 2020).

These groups are an essential part of the population who can contribute to controlling the transmission of the virus (Patterson & Margolis, 2019, as cited in Stokes et al., 2020). For example, in Country A, if the infection initially spreads among the working community and the country involves intragenerational social interaction (horizontal social interaction), then the disease is expected to spread at a slower rate in the older population (Bayer & Kuhn, 2020). Conversely, if there is a high level of intergenerational contact, as in Country B (vertical social interaction), then the virus is expected to spread quickly in the older population, resulting in initially high CFRs (Bayer & Kuhn, 2020).

Figure 2: Schematic country differences in inter- and intra-generational and social interactions

Figure 1: Schematic country differences in inter- and intra-generational social interactions



(Bayer & Kuhn, 2020.)

Moreover, intergenerational contact increases the difficulty in preventing intergenerational co-residence (Fenoll & Grossbard, 2020). Since families are the main source of social interactions and contact, they also become a likely source for the spread of the virus, particularly for people belonging to high-risk groups who are prone to COVID-19 complications (Dorélien et al., 2020, as cited in Stokes et al., 2020).

Cumulative cases have positively correlated with the co-residence rates and the challenges of physical distancing and intergenerational proximity. Accordingly, the possibility of social distancing and self-quarantining among these generations is low, if not entirely impossible (Stokes et al., 2020).

A large proportion of people in Italy and Spain reside with older individuals, such as their parents or even grandparents, which increases their chances of contracting SARS-CoV-2 and maintaining high intergenerational contact (Iacovou, 2010; Dykstra, 2018; Reher, 1998; Esteve, 2020, as cited in Dudel et al., 2020). Italy and Spain are the countries that in the beginning of the pandemic had some of the highest CFRs worldwide (Iacovou, 2010; Dykstra, 2018; Reher, 1998; Esteve, 2020, as cited in Dudel et al., 2020). Notably, the 'sandwich generations' of adults—those who care for both younger and older individuals—are another risk factor in transmission (Dowd et al., 2020). Additionally, the load of mortality and severe cases demonstrates the relationship between the age structure of the population, the age distribution of early cases, and the intergenerational connections (Dowd et al., 2020).

Overall, the high infection rate among the elderly in Italy is explained through Italian cultural living practices (Dowd et al., 2020, as cited in Sudharsanan et al., 2020). Intergenerational housing is common, wherein parents, children, and grandparents live together in a single household (Sudharsanan et al., 2020). Significant levels of intergenerational contact and residential closeness between generations are maintained through daily interactions. Consequently, even if they do not live together, this rapidly increases the chances of the elderly becoming infected (Kalmijn & Saraceno, 2008; Istituto Nazionale di Statistica, 2020, as cited in Dowd et al., 2020).

Preventing the transmission of the virus among older generations can be most effective in countries with fewer intergenerational households, such as France (Esteve et al., 2020), where it is more common for the elderly to live with others who are 65 years of age or older (Esteve et al., 2020).

e) Means of Transportation

One of the risk factors for the spread of SARS-CoV-2 is transportation (Du et al., 2020, as cited in Wei et al., 2020). Wei et al. (2020) suggest that the mobility of the population and transportation convenience have enabled the rapid transmission of the SARS-CoV-2 virus (Fang et al., 2009, as cited in Wei et al., 2020). Additionally, researchers have proven that the infection rate may depend on the accessibility of transportation, as areas with no access to better modes of transportation exhibit a different rate of SARS-CoV-2 infections (Sy et al., 2021).

Wuhan, where the SARS-CoV-2 virus began, is considered the transportation, economic, cultural, and political hub of the Hubei province and central China (Wei et al., 2020). A vast amount of people residing in adjacent counties and working in the city of Wuhan travel daily by bus, car, or train to Wuhan and back (Wei et al., 2020).

Studies have confirmed that the temporary gathering of crowds in frontline workers' commutes, such as in public transportation, has a more significant effect on the spread of SARS-CoV-2 than that of population density (Almagro et al., 2021).

Overall, many people consider public transportation to be the primary or only means of transportation, which results in increased transmission of the virus and an unequal risk between population groups (De Vos, 2020; Laurencin and McClinton, 2020, as cited in Almlöf et al., 2020).

One observable pattern is the spread of the virus among individuals who were in Wuhan and then travelled by air or interprovincial trains (Riley, 2007, as cited in Wei et al., 2020). When the pandemic started, many people travelled from Wuhan back to their homes, ultimately spreading the virus to nearby locations (Riley, 2007, as cited in Wei et al., 2020). Employing spatiotemporal analyses and mapping, researchers have proven that counties near Wuhan had much higher infection rates compared to other counties in China (Wei et al., 2020).

Therefore, counties connected via these transportation routes have exhibited an increased risk of infection, even after adjusting for factors such as the distance to Wuhan and population density (Du et al., 2020, as cited in Wei et al., 2020).

Scientists have also illustrated that the number of flights arriving in a city is associated with an increased number of infections (Pequeno et al., 2020). These numbers align with the expected role of air transportation in spreading the virus across countries (Ribeiro et al., 2020, as cited in Pequeno et al., 2020; Du et al., 2020, as cited in Wei et al., 2020). Research indicates that the number of COVID-19 cases imported by air is higher than the number imported by land (Dingil et al., 2021). However, the number of imported cases depends on the implemented measures (Dingil et al., 2021). Travel restrictions are one of the most effective measures against the transmission of SARS-CoV-2 from imported cases (Chinazzi et al., 2020, as cited in Tran et al., 2020).

f) Socioeconomic Status

Scientists have observed that the number of local cases have significantly varied across neighbourhoods (Lundkvist et al., 2020; Region Stockholm, 2020, as cited in Almlöf et al., 2020). For instance, lower socioeconomic areas have experienced a significantly higher number of cases than those belonging to higher socioeconomic classes (Lundkvist et al., 2020; Region Stockholm, 2020, as cited in Almlöf et al., 2020; Riou et al., 2021; Chen & Krieger, 2021). According to various studies, patients with lower median incomes from deprived areas are more likely to require intensive care and have a higher mortality rate (Quan et al., 2021; Ossimatha et al., 2021, as cited in Riou et al., 2021; Drefahl et al., 2020, as cited in Riou et al., 2021).

The positive association between infections with SARS-CoV-2 and socioeconomic position at the start of the pandemic may have been due to the following reasons: the large number of foreign travellers, the higher level of socialisation as a result of greater economic activity, and the presence of a higher testing capacity as well as better resources in wealthier regions (Abdellaoui, 2020). Residents of lower socioeconomic neighbourhoods have been found to have lower testing rates but higher morbidity and mortality rates; additionally, they are more likely to be admitted to a hospital than residents of wealthier neighbourhoods (Riou et al., 2021).

According to a Swiss study, residents in higher socioeconomic neighbourhoods are more likely to seek tests for COVID-19; accordingly, they have lower morbidity and mortality rates, and they comprise smaller numbers of severe COVID-19 cases that require admission to a hospital or intensive care unit (Riou et al., 2021). The increased risk of infection for people living in lower socioeconomic areas may be due to an increased infection risk at home and work (Riou et al., 2021; Almagro et al., 2021). Because of the nature of their jobs, people with manual occupations—who are often in lower socioeconomic classes—cannot work from home and usually experience a large number of unprotected social interactions (Riou et al., 2021; (Almagro et al., 2021).

Finally, research has indicated that hypertension, obesity and diabetes increase the risk of mortality from COVID-19, which is significant because poverty is a factor in developing these conditions (Guan et al., 2020; Marmot et al., 2010, as cited in Patel et al., 2020). Assessing different health outcomes from birth to death as well as illnesses (including cancer and infectious diseases) has revealed that the role of socioeconomic status in health outcomes is robust and valid (Chen & Krieger, 2020). For instance, people from regions with lower educational levels are more likely than others to experience worse health outcomes, such as diabetes, hypertension, and obesity (Abdellaoui, 2019, as cited in Abdellaoui, 2020).

g) Medical Care

Poor health generally increases the danger of COVID-19 (Dowd et al., 2020, p. 9697; Cohen et al., 2013; Liu et al., 2020; Cohen et al., 2015, as cited in Davies et al., 2020). Furthermore, the distribution of non-communicable comorbid conditions may differ depending on a person's age as well as other factors, such as undernutrition (Murray et al., 2015; IHME, 2020; Zhou et al., 2020, as cited in Davies et al., 2020). The severity of COVID-19 may also be significant in countries with low- and middle-income households (Davies et al., 2020, p. 1209). This may be due to the health system's poor capacity for intensive care treatment that is needed for severe cases (Davies et al., 2020). For example, having an inadequate health care system may lead to a lower testing rate of asymptomatic individuals or individuals with mild symptoms, and moreover a high mortality rate as a result of the lack of resources (Cortis, 2020). Conversely, regions with high health care expenditures have witnessed an increase in the number of COVID-19 cases (Ficetola & Rubolini, 2020), perhaps due to the rapid diagnosis of COVID-19 as well as the prompt and efficient reporting of these infections (Ficetola & Rubolini, 2020). However, countries with better health care systems tend to have a significantly larger percentage of people who are above 65 years of age (Ficetola & Rubolini, 2020).

2.2.2) Meteorological Factors

At the beginning of the pandemic, the WHO and other official institutions indicated that the SARS-CoV-2 virus spreads from person to person via large droplets that are exhaled through coughing, sneezing, and breathing (Kanj et al., 2020; Ghinai and McPherson, 2020; Qu, Li, et al., 2020, as cited in Maleki et al., 2021; Guo et al., 2020; Morawska & Cao 2020; Xie et al., 2009; Lindsey et al., 2012; Asadi et al., 2019; Bourouiba, 2020, as cited in Maleki et al., 2021; Maleki et al., 2021). Later in the pandemic, other avenues of infection were published, such as airborne infections spread through particles that contain the pathogen (Eissenberg & Kanj et al., 2020; Ghinai & McPherson, 2020; Qu, Li, et al., 2020, as cited in Maleki et al., 2021; WHO, 2020, as cited in Maleki et al., 2021; Huang et al., 2020, as cited in Elkington & Morgan, 2020). The WHO defines the airborne route as "the spread of an infectious agent caused by the release of droplet nuclei, which, if suspended in the air, remain infected for long distances and times" (WHO, 2014, as cited in Maleki et al., 2021, p. 2). Viruses such as SARS-CoV-2 dissolve in the mucous of symptomatic and asymptomatic patients and transform through rapid vapourisation into bioaerosols, which increases their lifespan in the air and their geographic spread due to their small size (Maleki et al., 2021). In Mongolia and China, people have become infected with the SARS-CoV-2 virus without any direct contact with infected people (Wang & Du et al., 2020, as cited in Maleki et al., 2021). This suggests that the airborne transmission of the virus through aerosols are a key in its spread (Wang & Du et al., 2020, as cited in Maleki et al., 2021).

a) Solar Radiation

Mendez-Arriaga (2020) and several other researchers explain that the Middle East respiratory syndrome (MERS) and severe acute respiratory syndrome (SARS) are substantially affected by environmental changes (Mendez-Arriaga, 2020, as cited in Sharma et al., 2020). Thus, the increased solar radiation in warmer seasons may have a positive effect on the infection rate (Mendez-Arriaga, 2020, as cited in Sharma et al., 2020).

The transmission of MERS and SARS can be prevented by inactivating these pathogens through high solar radiation (Qu & Wickramasinghe, 2017, as cited in Pani, 2020). Since COVID-19 is instigated by the SARS-CoV-2 virus, which is related to both SARS and MERS, SARS-CoV-2 is likely to be susceptible to meteorological factors (Sharma et al., 2020). Research indicates that high solar radiation positively correlates with the reduced risk of people becoming infected with SARS-CoV-2 (Sharma et al., 2020). Conversely, low solar radiation positively correlates with the persistence and spread of SARS-CoV-2 (Sharma et al., 2020).

As proven with MERS and SARS, the transmission of SARS-CoV-2 can be prevented by incapacitating SARS-CoV-2 through high solar radiation (Qu & Wickramasinghe, 2017, as cited in Pani, 2020; Gupta et al., 2015; Qu & Wickramasinghe, 2017, as cited in Ahmadi et al., 2020; Poole, 2020, as cited in Pequeno et al., 2020). Furthermore, insufficient exposure to solar radiation is associated with vitamin D deficiency in the hosts (Grant et al., 2020, as cited in Pequeno et al., 2020). Compared to tropical regions, colder regions experience lower exposure to solar radiation and report more cases of patients with vitamin D deficiencies, which leads to a decreased immune system response (Cannell et al., 2006, as cited in Sarkodie & Owusu, 2020; Fuhrmann, 2010, as cited in Sarkodie & Owusu, 2020). Vitamin D is an essential factor in reducing SARS-CoV-2 morbidity and mortality (Grant et al., 2020, as cited in Sarkodie & Owusu, 2020).

b) Temperature

Diurnal and Annual Temperatures

High temperatures are positively correlated with a reduced risk of people becoming infected with SARS-CoV-2, whereas low temperatures have demonstrated a positive correlation with the persistence and spread of SARS-CoV-2 (Sarkodie & Owusu, 2020; Ficetola & Rubolini, 2020; Ma et al., 2020; Wang et al., 2020b; Jia et al., 2020; Wei et al., 2020; Casanova et al., 2010, as cited in Sharma et al., 2020; Lu et al., 2020, as cited in Islam et al., 2020; Fu et al., 2021; Lui et al., 2020; Lin et al., 2020d; Xie & Zhu, 2020, as cited in Zu et al., 2020; Rashed et al., 2020; Pani et al., 2020). High temperatures decrease “the viability, stability, survival, and transmission of COVID-19” (Sarkodie & Owusu, 2020, p. 1). Laboratory tests prove that SARS-CoV-2 is temperature sensitive, degrades faster in warmer environments, and is more stable in colder climates (Kaplin et al., 2021; van Doremalen et al., 2020, as cited in Fu et al., 2021; Chin et al., 2020, as cited in Wei et al., 2020). A colder environment facilitates the emission of drifting and vapourising droplets, leading to an increased infection risk, which is demonstrated by higher infection rates in cold conditions (Fu et al., 2021; Davis et al., 2016a, 2016b; as cited in Ma et al., 2020).

Several scientists have researched the exact effects of temperature on SARS-CoV-2 infection risk. For such analyses, several ways of measuring the effect of temperature have been utilised. Outbreaks of COVID-19 are particularly visible in areas where the annual mean temperature is low (defined as 37° F–63° F/~3° C–17° C); this is compounded by the fact that less than 6% of all COVID-19 cases occur in countries with annual average temperatures of a minimum of 64° F/~18° C (Ahmadi et al., 2020, p. 2). Araujo and Naimi (2020) support the claim that colder regions predominantly suffer from the COVID-19 pandemic, as 95% of all infections globally have occurred in regions with temperatures of 28° F–50° F/~2° C–10° C. The increased presence of COVID-19 cases in colder regions compared to warmer regions is depicted by the virus' longer survival in environments with lower diurnal temperature ranges and its stability at 4° C as well as its instability in the presence of heat (Araujo & Naimi, 2020, as cited in Ahmadi et al., 2020; van Doremalen et al., 2020, as cited in Fu et al., 2021). Islam et al. (2020) reveal that the relative risk of virus transmission decreases when the maximum temperature is higher than 27° C and increases at lower temperatures (Islam et al., 2020).

Seasonal Temperature

Kaplin et al. (2021) explain that influenza, SARS, and SARS-CoV-2 follow seasonal infection patterns (Kaplin et al., 2021; Shaman et al., 2009; Shaman et al., 2010; Fuhrmann, 2010; Kampf et al., 2020; Lowen & Steel, 2014, as cited in Ficetola & Rubolini, 2020). Generally, as with the majority of seasonal respiratory pathogens, coronaviruses are influenced by the Northern Hemisphere's seasons, which lead to high infection rates in colder months and low infection rates in warmer months (Kaplin et al., 2021; Ficetola & Rubolini, 2020).

Thus, one can understand why SARS-CoV-2 infections are more frequent in winter (Heimdal et al., 2019, as cited in Byass, 2020). In addition to the virus being less stable in warmer climates, these seasonal changes in the Northern Hemisphere's infection rates are likely to be affected by human immune response and susceptibility (Ficetola & Rubolini, 2020; Sarkodie & Owusu, 2020; Wang et al., 2020b).

In the 2020 European winter, the second COVID-19 wave led several European countries to a higher infection rate than the first wave, proving that a lower temperature is key in the spread of SARS-CoV-2 (Fu et al., 2021).

Moreover, with the lower temperatures in autumn and winter, additional factors contribute to the spread of the virus, such as increased indoor gatherings due to cooler temperatures and poor air circulation due to windows being closed to maintain warmth in indoor areas (Bunker et al., 2016, as cited in Ma et al., 2020; Sharma et al., 2021; Guo et al., 2020). Although people maintain their distance, indoor spaces with poor ventilation enhance the distribution of aerosols and increase infection risk (Liu et al., 2020; van Doremalen et al., 2020, as cited in Guo et al., 2020). A fluctuating DTR lowers the human immune function (Shephard and Shek, 1998, as cited in Ma et al., 2020, p. 5), and changes between indoor and outdoor temperatures reveal the same effect on the human body (Donaldson et al., 1999, as cited in Ma et al., 2020).

Other factors also affect the transmission of SARS-CoV-2: the host's vulnerability toward the virus increases in colder and dryer environments due to the decrease of the airway mucosal surface defence through, for example (Clary-Meinesz et al., 1992, as cited in Wei et al., 2020), “a slower mucociliary clearance, or a decreased host immune function under harsher conditions” (Lowen & Steel, 2014; Tamerius et al., 2013, as cited in Ficetola & Rubolini 2020, p. 6). Furthermore, the increased vulnerability of human hosts in a colder environment has been proven through in vitro experiments (Luo et al., 2017). Cold air can result in bronchial constriction and reduced lung function, facilitating an increased vulnerability to pulmonary infections (Martens, 1998; Donaldson et al., 1999, as cited in Ma et al., 2020).

c) Humidity

Absolute and Relative Humidity

To understand the discussion concerning COVID-19 and meteorological factors, it is important to differentiate between AH and RH. Research reveals a significant positive correlation between AH, RH, and the number of COVID-19 infections (Islam et al., 2020).

> **Absolute humidity** is the measure of water vapor (moisture) in the air, regardless of temperature. It is expressed as grams of moisture per cubic meter of air (g/m^3). The maximum absolute humidity of warm air at 30°C/86°F is approximately 30g of water vapor – $30g/m^3$. The maximum absolute humidity of cold air at 0°C/32°F is approximately 5g of water vapor – $5g/m^3$.
>
> **Relative humidity** also measures water vapor but **RELATIVE** to the temperature of the air. It is expressed as the amount of water vapor in the air as a **percentage** of the total amount that **could** be held at its current temperature. Warm air can hold far more moisture than cold air meaning that the relative humidity of cold air would be far higher than warm air if their absolute humidity levels were equal. (Zehnder, 2014)

Several studies have proven a strong correlation between humidity and the spread of SARS-CoV-2; a high RH leads to a reduced infection risk, while a low RH increases the risk of SARS-CoV-2 infection (Sarkodie & Owusu, 2020; Ma et al., 2020; Wang et al., 2020b; Jiwei et al., 2020; Islam et al., 2020; Pani et al., 2020).

SARS-CoV-2 is sensitive to higher AH levels (Ma et al., 2020). Thus, humidity is a factor in the spread of COVID-19 (Liu et al., 2020). This finding is supported by the fact that AH is low in winter during the influenza season (Shaman et al., 2011, as cited in Liu et al., 2020). Furthermore, research indicates that the majority of global infections have occurred in dry climates (Araujo & Naimi, 2020). Therefore, AH has a stronger effect on the SARS-CoV-2 transmission rate than RH (Ma et al., 2020, as cited in Islam, 2020).

AH has a stronger effect on the spread of respiratory disease; however, Sarkodie and Owusu (2020) establish that high RH reduces the time of survival and with it the transmission rate of the virus (Sarkodie & Owusu, 2020, p. 1). In low humidity, SARS-CoV-2 is spread through aerosols, which increases the transmission risk of the virus and leads to reduced immunity (Sarkodie & Owusu, 2020, as cited in Fu et al., 2021). SARS-CoV-2 is more stable in environments with low AH, which increases the risk of spread (Lowen et al., 2007, as cited in Liu et al., 2020). Dry air may enable droplets to float and vapourise, which favours the transmission of SARS-CoV-2 (Fu et al., 2021). While large aerosol particles of 10 µm require only 10 minutes to fall to the ground, smaller aerosol particles with 2 µm need three hours to do the same (Marr et al., 2019, as cited in Fu et al., 2021). Consequently, a dry environment supports the presence of the virus in the air for a longer time than humid air and leads to increased infection numbers (Fu et al., 2021). Additionally, dry air decreases the interception and cleaning function of the mucous membranes of the upper respiratory tract, leading to a decreased host immune function, which leads to an increased host susceptibility to the virus (Hälinen, 2000, as cited in Fu et al., 2021; Lowen & Steel, 2014, as cited in Ficetola & Rubolini; Clary-Meinesz et al., 1992, as cited in Wei et al., 2020). While the SARS-CoV-2 virus is more stable in dry atmospheres, it can still spread and cause harm in countries with high humidity (Ahmadi et al., 2020).

Seasonal Humidity

The Northern Hemisphere's lower humidity in winter could partially explain how the seasons affect the spread of SARS-CoV-2 (Ma et al., 2020). The connection of the virus to humidity was seen in China's first wave of COVID-19, which occurred in winter and the beginning of spring when the AH was low, which allowed the SARS-CoV-2 virus to remain longer in the air and thus increase its transmission (Liu et al., 2020). The negative correlation between high humidity and increased infection rates can be explained in different ways. Ficetola and Rubolini (2020) argue that local and seasonal climates influence the spread of the virus and lead to patterns of SARS-CoV-2 infections (Ficetola & Rubolini, 2020).

This phenomenon has been documented in several indoor locations wherein airborne SARS-CoV-2 particles have been detected (see Chapter 2.2.2).

d) Wind Speed

Wind speed also influences the spread of SARS-CoV-2 (Anderson et al., 2020). Gravity causes larger droplets to quickly settle to the ground, whereas smaller droplets spread over a greater distance (Mittal et al., 2020, as cited in Li et al., 2020). These small droplets quickly evaporate into aerosols, which are also called *droplet nuclei*, leading to an increased long-distance infection risk (Li et al., 2020). Transmission through these aerosols is called *airborne transmission* (Booth et al., 2005, as cited in Li et al., 2020). Environmental factors such as humidity and temperature affect the spread of droplets, especially their spread distance and duration of viability (Wang, 2020, as cited in Li et al., 2020; Li et al., 2020; Fontes et al., 2020). Research has verified that warm climates with low RH allow droplets to easily shrink through vapourisation; this affects the trajectory of the droplets (Li et al., 2020).

As van Doremalen et al. (2020) confirm, SARS-CoV-2-containing aerosols can survive up to three hours in the air (van Doremalen et al., 2020, as cited in Li et al., 2020), which explains the presence of SARS-CoV-2-positive particles in the atmosphere of SARS-CoV-2-positive patients' rooms (Chia et al., 2020, as cited in Li et al., 2020; Ong et al., 2020, as cited in Bourouiba, 2020). These aerosolised droplets transport pathogens, and consequently, the aerosols containing the pathogens can be risky for individuals inhaling them (Li et al., 2020).

Research has confirmed a positive correlation between average wind speed and local transmission of the SARS-CoV-2 virus (Gomez-Barroso et al., 2017; Lopez et al., 2014; Mahamat et al., 2013, as cited in Wei et al., 2020; Wei et al., 2020; Jia et al., 2020; Lu et al., 2020, as cited in Islam, 2020; Coşkun et al., 2020; Rashed et al., 2020). Additional research has found that higher wind speed is crucial in the spread of SARS-CoV-2 by influencing the dynamics of the virus (Wei et al., 2020; Ellwanger & Chies, 2018, as cited in Pani, 2020). Increased wind speed transports aerosols over a wider distance, thus increasing the risk of aerosol transmission along with the distance (Li et al., 2020; Ahmed et al., 2020; Wei et al., 2020, p. 5; Coşkun et al., 2020).

Further research presents that wind speed is a factor in the prolonged "activation and infectivity of the virus" (Sarkodie & Owusu, 2020, p. 1). Islam et al. (2020) find that an increased wind speed stronger than 21 km/h is associated with an elevated infection risk (Islam et al., 2020). Wind speed influences the suspension time of SARS-CoV-2 as well as the distance of its spread (Islam et al., 2020). Aerosols can spread over a distance of six metres when the wind speed is between 1.1 m/s and 4.2 m/s (Dbouk & Drikakis, 2020, as cited in Li et al., 2020).

Wei et al. (2020) indicate that wind speed and population density are connected and together affect the SARS-CoV-2 infection rate (Wei et al., 2020; Coşkun et al., 2020). Logically, the virus spread increases in areas with high population densities (Coşkun et al., 2020). Coşkun et al. (2020) demonstrate that the likelihood of the wind transporting the virus increases when the wind speed is at least 30 km/h or stronger; this in turn increases the likelihood of people becoming infected (Coşkun et al., 2020). Furthermore, seasonal influences have been noted (Coşkun et al., 2020). Wind speed is higher in autumn, leading to increased transmission (Coşkun et al., 2020).

e) Air Pollution

Particulate Matter 2.5 and Particulate Matter 10

Multiple studies have found that air pollution is crucial in transmitting diseases by increasing humans' susceptibility to infectious respiratory illnesses (Chen et al., 2010; Peng et al., 2020; Ye et al., 2016, as cited in Wu et al., 2020b, p. 16; Castranova et al., 2001; Chauhan & Johnston, 2003; Jaspers et al., 2005, as cited in Hendryx & Luo, 2020). Since air pollution is a part of the transmission of the SARS-CoV-2 virus, it is beneficial to define air pollution:

> Air pollution is defined as a mixture of natural or anthropogenic compounds in indoor or ambient air including solid particles (such as particulate matter [PM], bioaerosols), liquid (droplets) and gases (carbon monoxide [CO], nitrogen [NOx] and sulfur [SOx]). Among these substances, PM is the most widespread health threat in cities. (Singh 1995; Block and Calder´on-Garcidueñas, 2009; Allen, 2015, as cited in Maleki et al., 2021, p. 2)

Air pollution is an important factor in respiratory diseases such as COVID-19 (Conticini et al., 2020). Many medical studies have demonstrated an association between poor air quality and the formation or worsening of chronic inflammatory sicknesses (Alves et al., 2018; Gulati & Brunner, 2018; Sigaux et al., 2019, as cited in Conticini et al., 2020). This finding corresponds with the fact that individuals living in areas with high air pollution face an increased risk of developing chronic respiratory diseases and are more prone to infective agents (Conticini et al., 2020).

Several studies have indicated that exposure to air pollutants leads to inflammation, cellular damage, and suppression of early immune response to infectious diseases, resulting in increased likelihood of worse infection outcomes (Tsai et al., 2019; Pope et al., 2016; Conticini et al., 2020; Becker & Soukup, 1999; Kaan & Hegel, 2002; Lambert et al., 2003a; Lambert et al., 2003b, as cited in Wu et al., 2020b).

Research has also established that air pollution weakens the immune system by transporting harmful microorganisms to the respiratory system, thus increasing susceptibility to respiratory diseases (Becker & Soukup, 1999; Cai et al., 2007; Horne et al., 2018; Xie et al., 2019; Xu et al., 2016, as cited in Zhu et al., 2020; Kamaruddin et al., 2015; Suhaimi et al., 2017; Awang et al., 2019; Sopian et al., 2020, as cited in Suhaimi et al., 2020; Becker & Soukup, 1999; Cai et al., 2007; Horne et al., 2018; Xie et al., 2019; Xu et al., 2016, as cited in Zhu et al., 2020).

Air pollutants weaken the cilia in the upper airways, which are the first lines of defence (Cao et al., 2020, as cited in Conticini et al., 2020). Consequently, individuals living in areas with high levels of air pollution are at increased risk of developing chronic respiratory illnesses (Cao et al., 2020, as cited in Conticini et al., 2020). Long-term exposure to air pollution can impair lung function and lower resistance to viral infections (Chauhan & Johnston, 2003; Gotschi et al., 2008; Yang et al., 2020, as cited in Hendryx & Luo, 2020).

SARS-CoV-2 is affected by air pollution (Bashir et al., 2020, as cited in Maleki et al., 2021). Hendryx and Luo (2020) argue that, although they did not focus on the short-term effects of pollution and the infection rate of SARS-CoV-2, the long-term effect of pollution correlates strongly with the infection rate of the virus (Hendryx & Luo, 2020).

Research indicates a correlation between a higher concentration of air pollutants and increased COVID-19 morbidity and mortality rates (Contini & Costabile, 2020; Domingo & Rovira, 2020; Nethery et al., 2020, as cited in Maleki et al., 2021). Due to its high frequency in the air, PM concentration is the main measurement category of air quality (IAMAT, 2020). PM is associated with both short- and long-term health risks (IAMAT, 2020). Experiments in a well-controlled quasi-experimental environment have verified a link between long-term exposure to PM and hospitalisation of pneumonia patients (Pope et al., 2004; Pope, 1989, as cited in Wu et al., 2020b). For clarity, PM, PM 2.5, and PM10 are defined below*:*

> Particulate Matter (PM) is defined as a heterogeneous mixture of suspended liquid droplets and solid particles with various size, shape, and chemical features, with spatial-temporal variations that are present in the ambient urban air. (Potukuchi & Wexler 1995; Ezzati et al., 2009; Hoek et al., 2011, as cited in Maleki et al., 2021, p. 2)
>
> Ambient PM differs in size and due to that reason is classified into different size fractions: particles with diameter ≥ 2.5 μm and ≤ 10 μm (PM10); fine particles with diameter ≤ 2.5 μm (PM2.5); PM10 that is the sum of the coarse and fine PM, and the ultrafine particles with diameter ≤ 0.1 μm (PM0.1) (Block and Calder´on-Garcidue˜nas, 2009; Hamid et al., 2019; Savastru et al., 2019, as cited in Maleki et al., 2021, p. 2).

PM2.5 and PM10 are utilised to analyse air quality (IAMAT, 2020). PM2.5 is of particular concern, as its small size allows it to penetrate deep into the cardiopulmonary system (IAMAT, 2020). Based on WHO guidelines, a maximum level of 10 µg/m^3 of PM2.5 should not be exceeded (IAMAT, 2020), as exposure to PM2.5 is related to a variety of "cardiovascular and respiratory comorbidities" (Wu et al., 2020b, p. 15); these have a significant effect on a patient's COVID-19 mortality risk (Wu et al., 2020b).

Wu et al. (2020b) conclude that the increased COVID-19 mortality associated with PM2.5-induced comorbidities is a result of PM-induced inflammation and cellular damage (Tsai et al., 2019; Pope et al., 2016; Conticini et al., 2020, as cited in Wu et al., 2020b; Conticini et al., 2020). Likewise, Wu et al. (2020b) reveal that PM2.5 is connected to worse outcomes respiratory infections, including influenza, SARS, and pneumonia (Wu et al., 2020b).

Studies have revealed positive correlations between COVID-19 morbidity and mortality rates and exposure to higher levels of PM2.5 diesel PM (Hendryx & Luo, 2020; Pansini & Fornacca, 2020, as cited in Suhaimi et al., 2020). This aligns with the research results of Wu et al. (2020b), which indicate that higher COVID-19 mortality rates are associated with an increased PM2.5 level (Wu et al., 2020, as cited in Hendryx & Luo, 2020).

Zhu et al. (2020) argue that PM2.5 is correlated with increased risk of infection with SARS-CoV-2 and that short-term exposure has the same effect (Zhu et al., 2020). Prolonged exposure to PM2.5 is connected to certain comorbidities, such as cardiovascular and respiratory sicknesses, that are linked to more severe COVID-19 cases and increased chances of COVID-19-induced deaths (Wu et al., 2020b; Brook et al., 2010; Pope et al., 2004; Pope et al., 2020, as cited in Wu et al., 2020b).

Frontera et al. (2020) state that the most significant outbreaks have been seen in the most polluted regions and directly connect PM2.5 levels with higher SARS-CoV-2 infection rates (Frontera et al., 2020). While Frontera et al. (2020) were conducting their research, the countries with the highest COVID-19 infection rates were China and Italy, which seems logical, as both countries have substantial levels of air pollution (Frontera et al., 2020). Furthermore, the areas in these countries that were most heavily impacted by COVID-19 also have considerably high PM2.5 rates (Frontera et al., 2020).

Conversely, Coccia (2020) argues that PM10 is an essential factor in the spread of COVID-19 and that PM10 levels higher than 50 $\mu g/m^3$ are significant in the increased infection rate (Coccia, 2020, as cited in Maleki et al., 2021).

Setti et al. (2020) and Suhaimi et al. (2020) find a positive correlation between PM10 and SARS-CoV-2 infection rates (Suhaimi et al., 2020; Setti et al., 2020, as cited in Maleki et al., 2021). Additionally, based on hospital admissions of COVID-19 patients, increased severity (Phosri et al., 2019) and mortality (Yao et al., 2020) in COVID-19 cases are associated with increased PM10 levels (Phosri et al., 2019, as cited in Zhu et al., 2020; Yao et al., 2020a; Yao et al., 2020b, as cited in Maleki et al., 2021; Maleki et al., 2021).

Some researchers believe that PM2.5 and PM10 together are key factors that facilitate increased COVID-19 morbidity rates (Yao et al., 2020a; Yao et al., 2020b, as cited in Maleki et al., 2021), revealing a noteworthy relationship between atmospheric PM, specifically PM2.5 and P10, the COVID-19 infection rate (Yongjian et al., 2020, as cited in Maleki et al., 2021), and the hospitalisation rate of patients with respiratory diseases (Xie et al., 2019, as cited in Zhu et al., 2020).

Individual vulnerability to respiratory bacteria and viruses is increased by inhaling PM2.5 and PM10 (Castranova et al., 2001; Chauhan & Johnston, 2003; Jaspers et al., 2005; Yang et al., 2001; Yang et al., 2020; Hendryx & Lou et al., 2020).

An association has been proven between PM2.5 and PM10 and the numbers of confirmed COVID-19 cases in China (Zhu et al., 2020; Maleki et al., 2021). Yao et al. (2020a, 2020b) establish that an increase of PM2.5 and PM10 levels of 10 $\mu g/m^3$ leads to a 0.24% and 0.26%

increase in COVID-19-induced mortality, respectively (Yao et al., 2020a; Yao et al., 2020b, as cited in Maleki et al., 2021).

Viral pathogens can attach themselves to air particles, including pollutants, and survive longer in the atmosphere, leading to increased chances of a pathogen being absorbed by the lungs (Rabi et al., 2020, as cited in Suhaimi et al., 2020). This increases the infection risks as well as risks of health complications and death (Rabi et al., 2020, as cited in Suhaimi et al., 2020). Maleki et al. (2021) suggest that SARS-CoV-2 particles specifically attach themselves to atmospheric PM2.5 (Maleki et al., 2021). Supporting this theory, Setti et al. (2020) present in an experimental study that the RNA of the SARS-CoV-2 virus can be found in atmospheric PM10 particles, which enable the virus to remain viable in the air for longer periods; this theory can be connected to the high SARS-CoV-2 infection rate in Italy's Po Valley (Setti et al., 2020, as cited in Maleki et al., 2021; Setti et al., 2020, as cited in Maleki et al., 2021; Suhaimi et al., 2020).

Atmospheric PM has been found to contain more pathogens during higher air pollution periods than during lower air pollution periods (Zou et al., 2016, as cited in Maleki et al., 2021). Several researchers have illustrated that viruses can exist in PM particles for approximately three hours (Rivera et al., 2020; Bushmaker et al., 2020, as cited in Maleki et al., 2021).

Specifically, the PM could increase the airborne transmission of viruses; for example, during a cold season in Beijing, PM2.5 was connected to an increased infection risk with influenza-like illnesses (Feng et al., 2016, as cited in Maleki et al., 2021).

PM2.5 remains in the air for longer than PM10, as this fine and light particle holds microscopic solids or liquid droplets that, due to their minimal size, can lead to serious health problems if inhaled, as they can bypass the upper respiratory tract and penetrate the lungs (Wu et al., 2020b; Frontera et al., 2020). The same effect of virus transportation with PM2.5 can be seen with SARS-CoV-2 (Zhu et al., 2020).

Nitrogen Dioxide

Other studies have also linked air pollution to the worsening of chronic inflammatory diseases (Alves et al., 2018; Gulati & Brunner, 2018; Sigaux et al., 2019, as cited in Conticini et al., 2020).

There is a high likelihood that many COVID-19 patients have lower viral immunity and preexisting respiratory sicknesses due to exposure to air pollution (Suhaimi et al., 2020).

Nitrogen dioxide (NO_2) seems to be a critical factor in this scenario, as a research study in Thailand establishes that NO_2 is connected to an increased likelihood of hospital admission due to respiratory illnesses (Phosri et al., 2019, as cited in Zhu et al., 2020). NO_2 is the most common pollutant, as it comes from numerous sources, including vehicle emissions, and has a geographical distribution similar to that of PM2.5 (Ismail et al., 2019, as cited in Suhaimi et al., 2020; WHO, 2010, as cited in Frontera et al., 2020).

Generally, exposure to NO_2 increases a person's vulnerability to respiratory diseases (Chen et al., 2007, as cited in Zhu et al., 2020). As a free radical, NO_2 leads "to impaired tissue defences, increased inflammatory response and cellular damage" (Frontera et al., 2020, p. 257). It also worsens pulmonary damage (Frontera et al., 2020). While high short-term exposure to NO_2 can lead to sicknesses such as permeable pulmonary oedema, long-term exposure is associated with a greater risk of developing acute respiratory distress syndrome (Douglas et al., 1989, as cited in Frontera et al., 2020; Reilly et al., 2019, as cited in Frontera et al., 2020).

Research has confirmed that prolonged exposure to NO_2 decreases lung function and increases lung inflammation (van Zoest et al., 2020; Jalaludin et al., 2014; Kamaruddin et al., 2019, as cited in Suhaimi et al., 2020) as well as increased vulnerability to pneumonia (Frontera et al., 2020), which is linked to the weakening of pulmonary defence mechanisms and thus leads to increased mortality rates (Jakab, 1987; Parker et al., 1989; Gardner et al., 1977, as cited in Frontera et al., 2020).

‘Double-Hit’ Hypothesis

During the COVID-19 outbreak, the hardest-hit provinces in China and Italy have been the Hubei Province and the Po Valley, respectively; both exhibit high rates of air pollution (Frontera et al., 2020). In accordance with the significant morbidity and mortality rates, the most affected areas in Italy have presented either permanently high levels of PM2.5 and NO_2 or an increase in the two months preceding the COVID-19 outbreak (Frontera et al., 2020).

The high morbidity and mortality rates in these regions, Frontera et al. (2020) argue, are due to the so-called double-hit hypothesis (Frontera et al., 2020): the combination of PM2.5, NO_2, and SARS-CoV-2 “give a “double-hit” to the lungs leading to acute lung injury by attenuating tissue remodelling and influencing local inflammatory response” (Frontera et al., 2020, p. 257).

2.2.3) Sociocultural Factors

a) Mask Usage

Although COVID-19 has impacted the whole world, visible differences have been noted between the West and the East (Ruan & Leung, 2021). Many citizens have followed mask policies with little or no rejection; however, people in various countries have protested wearing masks (Huang, 2020b; Taiwan Centre for Disease Control, 2020b; Philipose, 2020).

Two factors have been found regarding compliance in wearing masks: trust in the government as well as sociocultural factors (Ruan & Leung, 2021). In this section, these concepts are analysed as factors that influence wearing a face mask.

Particularly during this pandemic, masks have been utilised more frequently in some parts of the world than in others (Ruan & Leung, 2021). For example, in East Asia, the cautious attitudes observed toward health crises and the resulting swift responses are the result of sociocultural factors (Ruan & Leung, 2021). Specifically, wearing face masks is considered an essential factor in controlling health crises (Ruan & Leung, 2021).

In East Asia, wearing face masks is not new to people as a result of the pandemic. In fact, wearing such masks is common and embedded in the region's culture (Hiestand & O’Neill, 2020). In these countries, people wear face masks for multiple reasons, such as withstanding air pollution and preventing the outbreak of certain allergies (Hiestand & O’Neill, 2020). People in East Asian countries also wear face masks to protect themselves from sunlight and to remain anonymous while in public, as masks offer a level of privacy (Hiestand & O’Neill, 2020). Additionally, it is considered polite to wear a face mask during the cold and influenza season (Hiestand & O’Neill, 2020). In East Asia, wearing a face mask was traditionally used to protect the face from sunlight while working in the fields (Hiestand & O’Neill, 2020). Face masks were also utilised in women’s fashion in certain eras, and they were considered a sign of modesty since it was inappropriate for a woman to display her face to men who were not part of her family (Hiestand & O’Neill, 2020).

Over the past century, the influenza and SARS pandemics have resulted in an increase in face mask usage in East Asia as a health measure (Hiestand & O’Neill, 2020). This has especially been observed during the COVID-19 pandemic to prevent or limit infection (Iwasaki & Grubaugh, 2020, as cited in Ruan & Leung, 2021). In several East Asian countries, wearing a face mask during the COVID-19 outbreak has been universally considered ‘hygiene etiquette’ (Hiestand & O’Neill, 2020), whereas in many Western countries, utilising face masks in public has not been common (Hiestand & O’Neill, 2020).

Past experience has instigated further effectiveness in controlling the COVID-19 outbreak (Ruan & Leung, 2021). Mask wearing was instituted as a measure during the 2009 influenza epidemic in Japan (Ruan & Leung, 2021). Many older citizens who witnessed this crisis have utilised this knowledge during the COVID-19 pandemic (Lim et al., 2020, as cited in Ruan & Leung, 2021). Similarly, South Korea has experience in this field because of the MERS outbreak (Song & Yang, 2016, as cited in Ruan & Leung, 2021), which resulted in increased levels of compliance with implemented health measures (Ruan & Leung, 2021).

This aforementioned behaviour, which resulted from the experience with the SARS pandemic, can also be observed in China, Hong Kong, and Macao, where citizens and governments quickly recognised the importance of wearing a face mask as a preventive measure (Ruan & Leung, 2021). This importance can be observed through the behaviour of many citizens of Hong Kong who purchased large amounts of PPE (Ruan & Leung, 2021).

b) Trust in the Government

Although several international organisations, such as the WHO, have recommended specific NPIs, such as wearing face masks and maintaining social distancing requirements, many have failed to follow these recommendations and even frequently opposed them (Torres Lajo et al., 2021). In addition to the aforementioned reasons for wearing face masks, government-implemented health measures are a crucial factor in controlling the pandemic and reducing the spread of the virus (Torres Lajo et al., 2021; Han et al., 2020).

Several studies have illustrated that following implemented measures exhibits a strong connection to trust in the national government: the higher the level of trust in the government, the more citizens follow implemented measures (Travaglino & Moon, 2021, as cited in Ruan & Leung, 2021; Han et al., 2020). Overall, trust in the government refers to the current state of the national economy and how citizens perceive the state of the national economy. The state's capability to address the economic consequences of a crisis is considered the main determinant of trust (Citrin & Green, 1986; Miller & Borelli, 1991, as cited in Han et al., 2020). Citizens' negative perceptions of the national economy invoke distrust toward the government (Citrin & Green, 1986; Miller & Borelli, 1991, as cited in Han et al., 2020). Many studies have also demonstrated that trust in the government results in "spontaneous sociability, which in turn leads to cooperative, altruistic, and extraterritorial behaviours in social activities" (Fukuyama, 1995; Hetherington, 1995,as cited in Han et al., 2020, p. 2). Research has also revealed that high levels of trust in the government make citizens more willing to endure material sacrifices (Hetherington & Husser, 2012; Rudolph & Evans, 2005; Scholz & Lubell, 1998, as cited in Han et al., 2020). Generally, the success of such measures depends on compliance and support from the citizens (Han et al., 2020).

Significant levels of trust also lead to pro-social behaviour (Han et al., 2020): personal preventative measures were utilised during the swine flu (Rubin et al., 2009, as cited in Han et al., 2020), social distancing requirements were maintained during Ebola (Blair et al., 2017, as cited in Han et al., 2020), Ebola vaccines were received (Vinck et al., 2019, as cited in Han et al., 2020), influenza vaccines were received (Verger et al., 2018, as cited in Han et al., 2020), and financial compromises were made for the environment (Taniguchi & Marshall, 2018). Therefore, one can surmise that low levels of trust in the government cause individuals to be less likely to follow or even to reject the implemented measures (OECD, 2013, as cited in Torres Lajo et al., 2021) and to prioritise instant but incomplete benefits (Gyorffy, 2006, as cited in Han et al., 2020).

As in other health crises, the same pattern has been observed in the current pandemic (Han et al., 2020). During this health crisis, high levels of trust in the government have increased the probability of individuals applying preventative measures, such as wearing face masks, maintaining social distance, quarantining, handwashing, and avoiding crowded places, to reduce the spread of the virus (Han et al., 2020). Concurrently, low levels of trust in the government may thwart efforts to control COVID-19 (Lloyd-Sherlock et al., 2020, as cited in Han et al., 2020). This trust depends on several factors, including citizens' belief in the leadership skills of their government (Monaco et al., 2021) and the joint responsibility shared by citizens and the government (Monaco et al., 2021).

During a health crisis, the government must publish transparent, accurate, and timely information regarding the crisis, which improves trust in the government (Ruan & Leung, 2021). This behaviour fosters the needed trust (Kwon, 2020, as cited in Ruan & Leung, 2021) during a pandemic and has been observed in South Korea and Japan during the COVID-19 pandemic (Ruan & Leung, 2021).

Furthermore, each government must make the published information accessible to older people (Ruan & Leung, 2021). If a government do not inform citizens or inform them insufficiently regarding a pathogen, then trust in the government decreases, as do levels of compliance with implemented health policies (Ruan & Leung, 2021). Disseminating information encourages citizens to undertake appropriate personal health measures to protect themselves (Lee & You, 2020, as cited in Ruan & Leung, 2021).

Therefore, governments must offer accurate and timely information regarding the pathogen while pinpointing and addressing misinformation (Ruan & Leung, 2021). The information offered should include the number of infected individuals, the capacity of the health care system, and any unambiguous health instructions that represent [the] government['s] transparency and effective communication (Norris, 2020; Worthy, 2010, as cited in Han et al., 2020, p. 8).

In the current pandemic, citizens must perceive their government as organised, equitable, and willing to provide clear information on COVID-19 (Han et al., 2020). On the one hand, citizens' perceptions of the government as organised correlate with pro-social behaviours associated with COVID-19 (Han et al., 2020). On the other hand, a lack of government transparency is one of the major reasons for distrust (Welch et al., 2005, as cited in Han et al., 2020).

Generally, increased government distrust leads to decreased acceptance of official information and kindles the spread of misinformation and fake news (Lau et al., 2020, as cited in Han et al., 2020). Such increased distrust can also invoke uncertainty among citizens regarding the government's reliability in implementing necessary measures, which can deter citizens from complying with implemented health measures (Torres Lajo et al., 2021).

Another factor that influences the level of trust in the government is perceived fairness, that is, citizens must perceive equity in treatment of all citizen by the government (Meredith et al., 2007, as cited in Han et al., 2020). Additionally, the provision of adequate PPE, such as masks, sanitiser, "epidemic-related information, [and] financial resources" (Jian et al., 2020, p. 2), contribute to trust in the government (Jian et al., 2020). Choi et al.'s study (2020) during the COVID-19 pandemic reveals a connection between the government's perceived capability to control the virus and the availability of sufficient PPE (Choi et al., 2020, as cited in Jian et al., 2020).

After analysing in this chapter the scientific literature about the factors that influence the spread of SARS-CoV-2, a research gap has become visible. The current scientific literature is primarily from one or, at most, two fields that only skim other factors that contribute to the spread of SARS-CoV-2, which leads to a lack of understanding and could lead to false results. Existing scientific research literature offers factors that affect the spread of SARS-CoV-2 which can be utilised to analyse a COVID-19 outbreak in Taiwan.

2.2.4) Nonpharmaceutical Interventions

Several studies that analysed the success of countries with low COVID-19 infection rates came to the conclusion that the risk mitigation measures that were implemented were the driving forces in keeping the infection numbers low (Ansah et al., 2021; Haug et al., 2020;

Talic et al., 2021). These studies tried to understand which NPIs were the most effective in the fight against the COVID-19 pandemic and agreed upon some common policies, while disagreeing about others

Ansah et al. (2021) showed that in Singapore “targeted, aggressive containment including swift and effective contact tracing and quarantine” (Ansah et al., 2021, p. 2) were efficient in keeping the infection rate low (Ansah et al., 2021). Immediate individual quarantine of infected people as well as immediate an efficient contact tracing for both people with close contact to infected people and potential cases due to their recent travel history, were especially efficient/effective (Ansah et al., 2021). The contact tracing was not only based on recent travel data and close contact to infected individuals but also on the data gathered by “security cameras, receipts, and work calendars are used to fill in the gaps in memory of those infected who are unable to recall their whereabouts” (Ansah et al., 2021, p. 4). Furthermore, towards the end of March 2020 the Trace Together app was developed. This app is able to track individuals’ location and to alert users who had been in contact with people that had tested positive (Ansah et al., 2021). Furthermore, Ansah et al. (2021) concluded that the reduced movement of the population, social distancing, reduced crowding, and lockdowns proved to be efficient measures in Singapore. Another factor that proved to be important was the open communication between the government and its citizens (Ansah et al., 2021). Ansah et al. (2021) found that social distancing has not been sufficient without the implementation of quarantine and contact tracing on an individual level.

Haug et al. (2020) argue that the most effective policies in the fight against the COVID-19 pandemic have been “curfews, lockdowns and closing and restricting places where people gather in smaller or large numbers for an extended period of time. This includes small gathering cancellations (closures of shops, restaurants, gatherings of 50 persons or fewer, mandatory home working and so on) and closure of educational institutions” (Haug et al., 2020, p. 1308). They argue that the measures that restricted individual movement, such as curfews and bans on non-essential movement and gatherings, seemed to be some of the most effective measured policies (Haug et al., 2020). Furthermore, they argue that the implementation of a lockdown includes several effective policies like closed borders and schools, the closure of non-essential businesses, and a ban on gathering (Haug et al., 2020). Even though these measures are very effective they come with a price to pay since they damage the national economy and human rights (Haug et al., 2020). That is why a replacement of these invasive policies with several appropriate less-invasive measures can be preferable to harsh measures like lockdowns (Haug et al., 2020). For example, border restrictions and social distancing were proven to be effective in the fight against the spread of COVID-19 (Haut et al., 2020). Ansah et al. (2021) and Haug et al. (2020) argue that communication between the state and its population and the government offering data about the current crisis are important factors that lead to increased understanding and support of citizens. The information shared by the government should include travel warnings, guidelines about safety in the workplace, and recommendations that people should stay at home if possible, continue social distancing, and self-isolate if they notice symptoms (Haug et al., 2020). Furthermore, when the government provided food and financial support during quarantine it significantly reduced the fears of individuals in quarantine (Haug et al., 2020).

Talic et al. (2021) showed that the most effective measures in the current pandemic have been mask wearing, social distancing, and hand washing as well as isolation and stay-at-home measures, quarantine, and universal lockdowns that have included the closure of schools and non-essential businesses. They also argue that the early implementation of universal lockdowns when the infection rate was low showed a significant effect in the reduction of the infection rate (Talic et al., 2021). Countries like "Australia, New Zealand, Singapore, and China" (Talic et al., 2021, p. 2) that implemented universal lockdowns showed a strong decrease in COVID-19 mortality (Talic et al., 2021). In the end, there is no NPI that "acts as a silver bullet on the spread of COVID-19" (Haug et al., 2020, p. 1307) but a combination of several interventions seems to be successful in the fight against the virus (Haug et al., 2020). There is no one-size-fits-all approach to solve the current issue of the pandemic (Haug et al., 2020).

3.) Methodology

This chapter explains the scientific approach, the epistemological and ontological considerations, the research strategy, the research design, the means utilised to collect data, the approach employed to analyse the collected data, the validity and reliability of the research, the challenges and risks of the research, and the ethics self-assessment of the researcher. These topics are explained step-by-step to offer an understanding of the methodology utilised.

3.1) Epistemological and Ontological Considerations

3.2.1) Epistemological Considerations

> The *Oxford Handbook of Epistemology* defines *epistemology* in the following way: epistemology, characterised broadly, is an account of knowledge. Within the discipline of philosophy, epistemology is the study of the nature of knowledge and justification: in particular, the study of (a) the defining components, (b) the substantive conditions or sources, and (c) the limits of knowledge and justification" (Moser, 2020, p. 3).

Audi (2014) calls *epistemology* the 'theory of knowledge' (Audi, 2014); in his view, the theory concerns "how we know what we know, what justifies us in believing what we believe, and what standards of evidence we should use in seeking truths about the world and human experience" (Audi, 2014, p. 1). Bryman (2008) states that epistemology discusses the issue of what can be accepted as knowledge in a field.

Since all methods have both limitations and strengths, many researchers argue that qualitative and quantitative research methods should be joined to overcome their faults (Tashakkori & Teddlie, 2003, as cited in Schoonenboom & Johnson, 2017). Therefore, this thesis utilises quantitative and qualitative data, leading to two epistemological considerations.

a) Positivism

Positivism is an epidemiological view that encourages the usage of natural science to study social phenomena (Bryman, 2008). Positivism believes that knowledge is based on the premise that the collection of facts leads to the basis for laws; this is called *the principle of inductivism* (Bryman, 2008). Furthermore, positivism states that science is objective; in other words, science can be performed in a value-free way, scientific and normative statements differ from each other, and scientific statements are the demesne of scientists (Bryman, 2008). The statement of the objectivism of science supports the argument that the senses cannot verify normative assertions (Bryman, 2008), because, as Guba and Lincoln (1994) state, the researcher and the studied object are independent beings, and the researcher can investigate the object without affecting it or being affected by it.

In this thesis, a positivist approach is utilised to analyse quantitative data. As Rafik (2014) argues, quantitative methods are based on positivist paradigms. Therefore, the analysis of the research literature begins with scientifically measured data that state a theory; hence, a positivist paradigm is appropriate, since the analysis follows statements that are verified through natural science. The analysis herein often considers the people analysed to be objects because medical analysis typically investigates the human body. Moreover, in some parts of the analysis, individuals are not included, and only the SARS-CoV-2 virus is investigated based on natural science, which fits the positivist paradigm. This stance is essential in this research since it aims to explain how certain factors influence the transmission of the SARS-CoV-2 virus.

b) Interpretivism

Interpretivism is the contrasting epidemiology to positivism (Bryman, 2008). In interpretivism, researchers analyse the social world through scientific models (Bryman, 2008). While positivism is often utilised in natural science, interpretivism is often utilised in social science (Bryman, 2008). Schutz (1962) explains the difference between positivism and interpretivism:

> the world explored by the natural science does not 'mean' anything to the molecules, atoms and electrons. But the observational field of social scientists—social reality—has a specific meaning and relevance structure for the beings living, acting and thinking within it (Schutz, 1962, p. 59, as cited in Bryman, 2008).

Hence, a significant difference between positivism and interpretivism is that interpretivism examines humans who see meaning in their social reality, and create their social reality, which is not the case in positivism (Byrman, 2008; Blaikie & Priest, 2019). That’s why the interpretivist paradigm is used in qualitative methods (Hanzel, 2010, as cited in Rafik, 2014).

3.2.2) Ontological Consideration

The ontological consideration addresses the following question: “What is the form and nature of reality and, therefore, what is there that can be known about it?” (Guba & Lincoln, 1994, p. 108). Ontology argues that if the real world humans perceive is only assumed, then how can scientists be sure of reality and real functionality (Guba & Lincoln, 1994), leading to the conclusion that the only questions that matter are those that instigate the discussion of true existence and actions (Guba & Lincoln, 1994).

Social ontology attempts to explain the nature of social realities (Bryman, 2008) by seeking to determine whether social realities should be seen as objective due to social actors' external realities or whether these social realities are built upon these social actors' perceptions and actions (Bryman, 2008). These two arguments comprise objectivism and constructionism (Bryman, 2008).

a) Objectivism

Objectivism is based on the idea that social science can adjust to the methods of natural science (David & Suton, 2004, as cited in Bahari, 2010) and that the social world can be viewed as real (Morgan & Smircich, 1980, as cited in Bahari, 2010).

The ontological theory of objectivism states that the meaning and existence of social phenomena exist independently of the social actor (Bryman, 2008; Neumann, 2003, as cited in Tuli, 2010). Research based on positivism sees this assumption as the only possible way to analyse knowledge objectively (Tuli, 2010). According to Davies et al. (1998), social science aims to identify a forecastable reality as objectively as possible (Davies et al., 1998, as cited in Bahari, 2010). Johnson (1987) argues that

> the classical objectivist view of knowledge assumes 'science' produces successive theories that progress ever and ever closer to *the* correct description of reality. Moreover, even though we will never achieve the final, complete account, it is believed that genuine empirical knowledge involves universal logical structures of inferences which results can be tested against theory-neutral 'objective' data (Johnson, 1987, as cited in Bahari, 2010, p. 25).

This research utilises quantitative and qualitative data. The quantitative data is based on the positivist epidemiology and therefore also the objectivist ontological consideration.

b) Constructionism

The view opposite of objectivism is constructionism, which assumes that reality is generated through social activities (Neuman, 2003, as cited in Bahari, 2010). Blaikie and Priest (2019) posit that constructionism argues that the social world can only be accessed through the language of research participants and that social reality must be investigated from the inside through research participants. In social science, there are no static and constant criteria for discovering whether knowledge is true (Blaikie & Priest, 2019). Bryman (2008) states that constructionism

> is an ontological position (often also referred to constructivism) that asserts that social phenomena and their meanings are continually being accomplished by social actors. It implies that social phenomena and categories are not only produced through social interactions but that they are in constant state of revision (Bryman, 2008, p. 19).

Recently however, researchers defining constructionism have begun to stipulate that researchers can only present a certain version of social reality rather than one that can be seen as the one and only true reality (Bryman, 2008). Since this research also contains qualitative data, the ontological consideration of constructionism is utilised.

3.3) Research Strategy

The research strategy can often be divided into quantitative or qualitative research methods (Bryman, 2008). Furthermore, Bryman (2008) mentions that the distinction between the two methods is more complex than merely stating that quantitative methods utilise measurements while qualitative methods do not. Many researchers distinguish the two approaches based on several factors, such as their epistemological and ontological foundations (Bryman, 2008). Bryman (2008) states that "by research strategy, I simply mean a general orientation to the conduct of social research" (Bryman, 2008, p. 22). This thesis utilises qualitative methods to analyse quantitative and qualitative data.

3.3.1) Quantitative Research

Quantitative research utilises natural science practices and norms, following the view that social reality is an external and objective research object (Bryman, 2008). Bryman (2008) states that quantitative methods are utilised in natural science models, especially in those that employ a positivist epistemological orientation or an objectivist ontological orientation. Blaikie and Priest (2019) add that in the majority of quantitative approaches, the researcher has little or no contact with the individuals they study. Several research papers that got analysed in this thesis fall under quantitative methods based on their foundation in positivism and objectivism.

3.3.2) Qualitative Research

Bryman (2008) states that qualitative methods are utilised in models that employ an interpretivist epistemological orientation or a constructionist ontological orientation. Furthermore, he explains that qualitative methods reject the approaches and norms of natural science and positivism, basing their interpretation of the observed social phenomena instead on the studied individuals and their interpretation of their social reality (Bryman, 2008). Moreover, qualitative research attempts to embody an individual's social life as constantly changing (Bryman, 2008).

Qualitative data of previous studies will be gathered and analysed in this thesis. The methods utilised in this thesis have their bases in interpretivism and constructionism; thus, they fall under qualitative research methods.

3.4) Research Design

Research design is “a strategic framework for action that serves as a bridge between research questions and the execution or implementation of the research" (Durrheim, 2007, p. 34). It establishes the plan that states how data will be collected and analysed (Sellitz et al., 1965, p. 50, as cited in Durrheim, 2007). It states and justifies the methods utilised in the research (Blaikie & Priest, 2019). Ideally, the research design is determined before the research begins and includes planning for all possible scenarios (Blaikie & Priest, 2019).

For this thesis, a case study is utilised to make the analysis meaningful. Bryman (2008) states that "basic case study entails the detailed and intensive analysis of a single case" (Bryman, 2008, p. 52), focussing on its complexities (Stake, 1995, as cited in Bryman, 2008). The word *case* in research is often utilised to denote a single location (Bryman, 2008). If this research had not been limited to one country, then the analysed data would not be robust since different factors influence different countries and regions. In this research, the location of the analysis is Taiwan, and the specific event is the COVID-19 pandemic in Taiwan. The complexity of this case was analysed and examined intensively from different perspectives and fields to create a holistic approach; data from quantitative and qualitative research were utilised to compensate for the weaknesses of the each method.

This approach is logical in a case study since, according to Bryman (2008), case studies are often connected to purely qualitative methods but can be utilised in both qualitative and quantitative research. Taiwan was chosen as the location since the nation's efforts during COVID-19 offer understanding regarding appropriate actions to increase success in reducing and preventing infections in a global pandemic. Additionally, Taiwan was chosen due to its approach. The nation acts mainly on a national level, while many other countries indicate strong federalism that is more difficult to analyse on a national level, as different states implement different strategies that influence each other.

In this case study, the COVID-19 pandemic data were gathered through scientific documents and in-depth, semi-structured interviews to acquire viewpoints from every possible angle and field.

Research question 1, 2 and 4 will be answered through data gathered from previous research while question 3 will be answered through the empirical data created through in-depth semi-structured interviews conducted by the author and partially through gathered data from previous research. Finally research question 5 will be answered through the analysis of previous research, collected data and interviews conducted by the author.

3.5) Data Collection

In this thesis data will be gathered through documents as well as through semi-structured interviews.

3.5.1) Documents as a Source of Data

In this study, quantitative and qualitative research papers, official state documents, and newspaper articles were utilised to gather data about the implemented NPIs. Research papers offered understanding of all four categories (socio-demographic, meteorological, and sociocultural factors as well as NPIs), and official sources offered infection numbers.

The research papers were utilised to gather as much data as possible about the four aforementioned factors, which were each divided into subcategories. With the gathered data, an analysis based on several scientific studies was implemented, and the validity and reliability of the data were controlled.

3.5.2) Semi-structured Interviews

Calls were published in Taiwanese social media groups to establish contact with interviewees in Taiwan. These calls stated that volunteers for COVID-19 research interviews were needed and that interested individuals should establish contact via email to participate or gain further information. The requirement for the interviewees was that they should have lived in Taiwan during the pandemic and hold Taiwanese citizenship and but not necessarily work in the health sector. After interested individuals established contact via email, further information about the interview and the consent form were sent to the interviewees. Further questions were answered in zoom meetings. The interviewees' consent was obtained for each interview in written form through the English consent form or verbal consent and got recorded separately from the interview and before the interview started. The author gained permission to record the interview for later analysis, and no personal data was included in the interviews. The semi-structured interviews were organised to allow the interviewees to express themselves, their thoughts, and their beliefs while the questions were a guide to return to the topic. After the first round of interviews, a snowball system was implemented where interviewees recruited potential interviewees who contacted the author via email. Through the snowball system a connection to potential interviewees of different backgrounds, gender, and age got quickly established. After answering questions and obtaining consent, these individuals were interviewed. All the interviews were held via zoom and took, on average, an hour. For this research, open-ended semi-structured interviews were utilised to question individuals about their beliefs, views, and professional experience with COVID-19. Health workers, such as nurses and doctors, and citizens were interviewed.

17 citizens were asked questions concerning mask wearing in Taiwan. These questions were mainly about their views regarding when and for whom masking is necessary or appropriate.

Moreover, the interviewees were asked about mask usage in Taiwan, their views of daily mask usage in pre-pandemic times, and the connection between mask usage and the SARS pandemic.

Furthermore, the interviewees were asked about their trust in the government, the effectiveness of implemented policies, Taiwan's success in COVID-19, the data published by the government, the treatment of Taiwanese citizens, and the availability and accessibility of medical supplies.

These questions were asked to examine the sociocultural factors of mask usage in Taiwan and whether a common view of mask usage could be found through the interviews. Furthermore, trust in the government was measured through the second part of the interviews, since this element is connected to following the implemented measures.

Out of these 17 Taiwanese citizens five were health workers which answered the same questions as the other citizens as well as additional questions based on their field experience regarding safety at their workspace, availability of personal protective equipment (PPE) and other necessary medical equipment, the treatment of health workers during the pandemic, problems they have faced, and the overall view of the pandemic in the health sector. These additional questions were utilised to better understand the medical sector and the needs and problems of frontline workers.

For the interviews, 17 Taiwanese citizens who lived in Taiwan during the COVID-19 pandemic were interviewed about mask-usage and trust in the Taiwanese government, additionally health workers were also interviewed about their experience in the health sector while the pandemic. The interviews took, on average, approximately one hour and utilised a semi-structured approach to acquire the interviewees' views in detail while restricting the interviews to specific topics.

3.6) Data Analysis

According to the Association for Educational Communications and Technology (2001), descriptive research does not fit neatly into the methodology of quantitative or qualitative research because it can employ both. This method applies to research questions, research design, and data analysis; it attempts to answer ‘what is’ questions (The Association for Educational Communications and Technology, 2001). According to Glass and Hopkins

(1984), “descriptive research involves gathering data that describe events and then organises, tabulates, depicts, and describes the data collection” (Glass & Hopkins, 1984, as cited in The Association for Educational Communications and Technology, 2001). The aim of descriptive analysis is to explain a phenomenon, and it is mostly concerned with finding an answer to ‘what’ questions (Nassaji, 2015). According to Kemp et al. (2018), descriptive analysis has proven to be flexible and customisable, leading to the usefulness and permanence of this method.

In this research, the data were gathered through scientific literature and semi-structured interviews. Since this research utilises both quantitative and qualitative data, a descriptive analysis was chosen to analyse these data. Furthermore, this method is appropriate because of the inductive nature of this study and that the research questions seek to describe ‘what is’. Initially, data were gathered through scientific literature found on Web of Science and Google Scholar using keywords such as COVID-19, Taiwan, socio-demographic, population, intergenerational living, meteorology, climate, temperature, humidity, culture, trust, and NPIs. The collected data were analysed to reveal “recurring themes, patterns and concepts” (Nassaji, 2015, p. 130) through the descriptive analysis. This led to the creation of categories and subcategories into which the data were sorted. The categories and subcategories were as follows:

Categories	**Subcategories**
Socio-demographic factors and health care	Population density
	Crowding
	Age distribution
	Intergenerational living
	Means of transportation
	Socioeconomic status
	Medical care

Meteorological factors	Solar radiation
	Temperature
	Humidity
	Wind speed
	Air pollution
Socio-cultural factors	Mask usage
	Trust in government
	SARS experience

These categories were analysed to create a framework based on current scientific knowledge of factors that affect the spread of SARS-CoV-2. Furthermore, the data in these categories and subcategories were analysed to reveal the connections and interdependencies between these factors. Thereafter, data in these categories were gathered specifically about Taiwan. When there was a lack of research data specifically about Taiwan, quantitative data were collected that were analysed through the established patterns and concepts of the preliminary descriptive analysis. These gathered data were also analysed to reveal "recurring themes, patterns and concepts" (Nassaji, 2015, p. 130) and were assigned certain categories.

The semi-structured interviews that were conducted with 17 participants from Taiwan were analysed to identify thematic patterns. Thematic analysis is one of the most popular qualitative methods used to analyse data and is often applied to analyse documents such as interview transcripts (Bryman, 2012). This approach is used to analyse qualitative data and to identify common themes "topics, ideas, and patterns of meaning" (Caulfield, 2021). For this approach, the interviews were transcribed on paper and coded in numbers. Mask wearing location received number one, mask wearing person number 2…

Themes were generated based on the coded data, and the codes were added to the generated themes.

Code	**Theme**
1: Mask wearing location	Mask usage
2: Mask wearing person	Mask usage

3: Reasons for mask wearing	Mask usage
4: Reasons against mask wearing	Mask usage
5: Mask wearing before the COVID-19 pandemic	Mask usage
6: Mask wearing after the COVID-19 pandemic	Mask usage
7: Socio-cultural impact of mask wearing	Mask usage
8: Trust in government	Trust in government
9: Organised and competent government	Trust in government
10: Critique of government	Trust in government
11: Preparedness of government	Trust in government
12: Early reaction of government	Trust in government
13: Government-published COVID-19 data	Trust in government
14: Transparency and reliability of data	Trust in government
15: Accessibility of data	Trust in government
16: Government’s treatment of citizens	Trust in government
17: Economic consequences	Trust in government
18: Supply of masks and sanitisers	Trust in government
19: Cooperation between government and citizens	Trust in government
20: Workspace safety in health sector	Health sector
21: Negative consequences in health sector	Health sector
22: Sufficient medical supplies	Health sector
23: Preparedness of health sector	Health sector
24: Policies in health sector	Trust in government
25: Governmental critique of health sector	Trust in government
26: Faced problems in health sector	Health sector

After generating themes and adding the generated codes to the appropriate themes, the categorised data were analysed to reveal patterns. To be sure the themes covered all the data gathered in the interviews, the transcripts were analysed to determine the accuracy of its content representation in the themes. Later, the interviews and the data gathered through the literature review were closely examined and interpreted to gain an understanding of whether the qualitative data gathered through the interviews supported or rejected the theories formulated based on the quantitative data. The nature of the data analysis can be said to be more qualitative, although it utilised quantitative and qualitative data.

3.7) Reliability and Validity

Validity and reliability are utilised as criteria to evaluate the quality of social research (Bryman, 2012). Reliability is employed to determine whether the research results can be repeated to find consistency in the concepts (Bryman, 2012). In quantitative methods, reliability also focusses on whether a measure is stable (Bryman, 2021).
While validity is often seen as the essential criteria in research, it inspects the integrity of the research conclusion. Validity can be divided into four categories: measurement validity, internal validity, external validity, and ecological validity (Bryman, 2012).
Measurement validity, also called *construct validity*, is typically utilised in quantitative research and examines the methods that measure concepts in social science to determine whether these reflect the social concept (Bryman, 2012).
Furthermore, validity and reliability go hand-in-hand:

> if a measure of a concept is unstable in that it fluctuates and hence is unreliable, it simply cannot be providing a valid measure of the concept in question. In other words, the assessment of measurement validity presupposes that a measure is reliable. If a measure is unreliable because it does not give a stable reading of the underlying concept, it cannot be valid, because a valid measure reflects the concept it is supposed to be measuring (Bryman, 2012, p. 47).

Internal validity typically engages with the question of causality and focusses on "question of whether a conclusion that incorporates a causal relationship between two or more variables holds water" (Bryman, 2012, p. 47).
External validity focusses on whether the research is generalisable and whether the results can be generalised beyond this specific study (Bryman, 2012). Finally, ecological validity investigates whether the findings of social research can be applied to the everyday lives of individuals (Bryman, 2012).

For this research, the case study method allowed the researcher to limit the data that had to be gathered regarding the current event—the COVID-19 pandemic—and the geographical location—Taiwan. The focus required in a case study allows the researcher to create an in-depth understanding of the case through data from different sources. Through in-depth research of scientific literature and semi-structured interviews, data can be gathered to generate a deep understanding of the situation. Furthermore, in this research, the collected data is utilised to explain the effect of specific variables on the spread of the SARS-CoV-2 virus in Taiwan and what can be learnt from Taiwan's success in fighting the virus.

This case study is reliable since the results of the study are repeatable. This can especially be seen in the literature by many other researchers that supports the results. If the research were to be repeated with the same variables, then the same conclusions would be produced based on the data that were utilised to analyse the case study.

Furthermore, this paper demonstrates measurement validity since the measurement utilised herein was also utilised in several studies researching the same variables. The usage of many research papers as a source of data allowed the researcher to verify that the results are valid and have external validity since several researchers in different studies in different regions of the world reached the same conclusion. Additionally, these interviews were compared to existing research literature to support the validity of the findings.

The internal validity is based on current COVID-19 literature, but due to the number of variables and the scant available research, it can only be assumed that these factors have a role in affecting the spread of the SARS-CoV-2 virus. The causality of the results is underscored by current research, but since this is a new virus, scientists have not had significant time to study its spread. Concurrently, the results of the interviews are supported through theories that have existed for years and indicate solid causation. This work is also ecologically valid since it examines the daily behaviour of people in the context of mask wearing, trust, and other factors that affect daily life. Furthermore, the results apply to people's everyday lives since they relate to the spread of the SARS-CoV-2 virus, which is part of people's daily lives worldwide and currently shapes a predominant part of reality.

3.8) Challenges and Risks

Due to the ongoing spread of the SARS-CoV-2 virus, the researcher avoided any physical contact with interviewees to avoid placing them at risk. To not pose a risk to the interviewees by possibly infected them with the SARS-CoV-2 virus travelling to Taiwan was not possible. This led to salutation that the interviews were conducted through Zoom since the Norwegian Centre for Research Data currently considers it to be one of the only safe ways to conduct interviews. The researcher faced in the beginning the challenge to establish contact to potential interviewees since it was not possible to establish contact to potential interviewees in the field. This issue kept the number of the participants for months low until a connection to some Taiwanese citizens got established that assisted with the recruiting of potential interviews through the snowball system. Especially establishing contact to health workers seemed challenging since none of the Taiwanese hospitals contacted via email answered. But after getting to know nurses through the snow balling system they connected me with further health workers. The language difference did not lead to any hurdle since all interviewees spoke fluently English.

3.9) Ethics Self-Assessment

When considering the nature of qualitative research, the interaction between the participant and the researcher is significant. Consequently, the risk of ethical challenges is higher than in quantitative research, and adhering to the guidelines provided by relevant authorities is vital to avoid ethical challenges. Therefore, maintaining the legality of personal data protection regulations at the professional level is essential in conducting a research project. For this research, the ethical issues that had to be considered are consent and confidentiality, as with every interview, maintaining the confidentiality of an interviewee's identity is necessary. Consequently, no personal data have been recorded or written in notes that could identify a participant. If an interviewee allowed recording the interview, then it occurred only with a device that could not be connected to the internet. This device was locked in a cupboard in a locked room. Before the interview, the interviewees were informed about every step of the interview and what they were agreeing to if they consented to be recorded.

Furthermore, the researcher informed the interviewees of the data usage and how their data would be protected. Consequently, they understood how the interviews would be conducted and were able to decide whether they wanted to be recorded. The interviewee could withdraw their consent at any time. An information letter was formulated that included “a declaration of consent to be signed by the participant” (University of Agder, n.d.). The data of these interviews were not shared with any third party, and the recorded data were not stored longer than necessary; additionally, they will be deleted after the end of the project (University of Agder, n.d.).

Chapter Four: Analysis of the Case Study of Taiwan

In this chapter, the gathered information through the analysis of scientific literature as well as the data collected through the semi-structured interviews will be in detail analysed in this chapter to gain an understanding of the factors influence on the spread of SARS-CoV-2 in Taiwan.

4.1) Taiwan's Socio-Demographic Factors and Medical Care

In this chapter the socio-demographic factors and the Taiwanese medical care will be analysed based on the gathered data presented in the literature review and data that collected from scientific and governmental sources through literature about Taiwan.

4.1.1) Population Density

Taiwan is a small island with 23.87 million people (Worldometer, 2021). This number is not high in comparison with other countries in East Asia, such as Japan, South Korea, or Mainland China; however, when compared to other countries with similar populations, such as Australia, one may realise that although the population size is generally the same, Taiwan is geographically smaller, which implies that the island must have a high population density. As previously mentioned, Taiwan has the 17th highest population density globally, with 649 people/km² (World Population Review, 2021); hence, Taiwan is more vulnerable to the propagation of respiratory diseases such as SARS-CoV-2 due to the limited space and resulting close contact with others, which means that people often find it challenging to maintain their distance (see Chapter 2.2.1).

In Taiwan, four cities have a population of over one million people.

Table 3: Taiwan's Largest Cities

City	Population Size	Population Density
Taipei City	7.8 million people	9,918 p/km²
Taichung City	2.82 million people	1,249.4 p/km²
Kaohsiung City	2.76 million people	941 p/km²
Tainan City	1.8 million people	860 p/km²

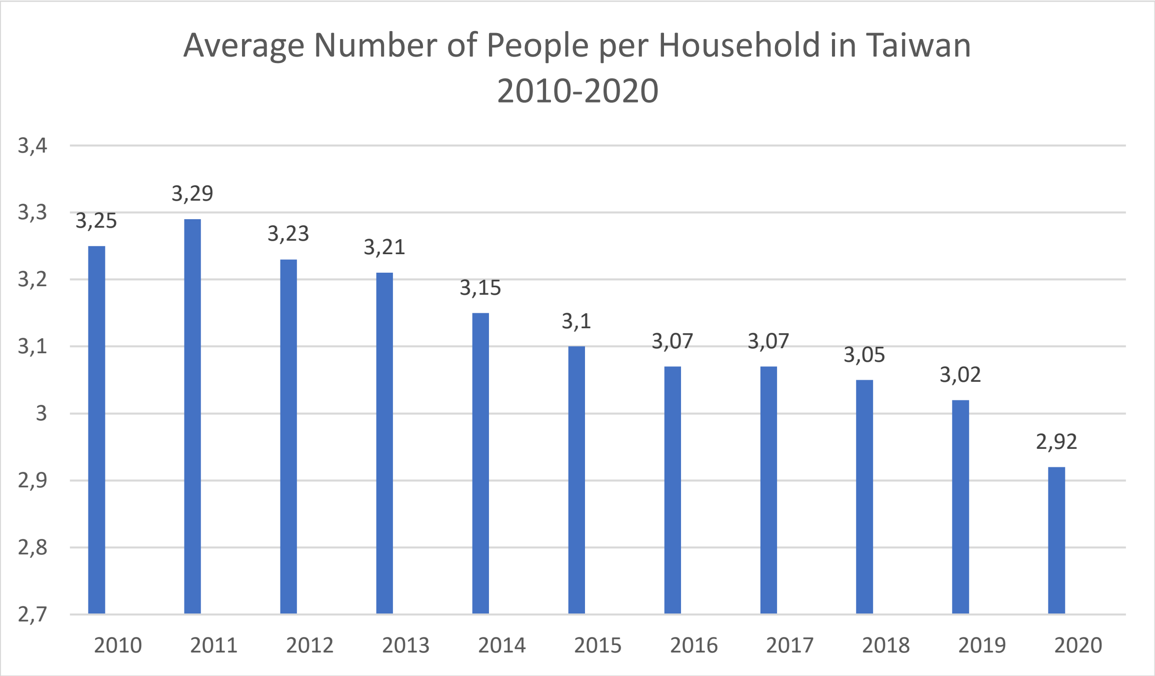
(Table generated by author based on World Population Review, 2021; Taipei City Government, 2021; Kaohsiung City Government, 2021; Population.City, 2021; Imani et al., 2021.)

The population density problem exists primarily in major cities like those in Table 3. In places with high population densities, it is difficult or sometimes even impossible to maintain the WHO-recommended distance, which is one reason for a wider spread of SARS-CoV-2 in such cities. With SARS-CoV-2, if people are unable to maintain appropriate distance from others, then they are within the radius where they can become infected with exhaled droplets that transmit SARS-CoV-2; they are also in the radius where aerosols can reach them. The high population density in Taiwan (World Population Review, 2021) means that many aerosols exist in a small area and little distance is maintained between people, which leads to an increased infection risk.

4.1.2) Crowding

As mentioned previously, according to Hamidi and Hamidi (2021), crowding, rather than population density, is the crucial factor in SARS-CoV-2 infections. The factors accounting for this crowding include average household size and crowding at tourist attractions. While population density is especially high, 2020 saw a reduction in Taiwan's household size (see figure 3) to 2.92 people per household (Statista, 2021n).

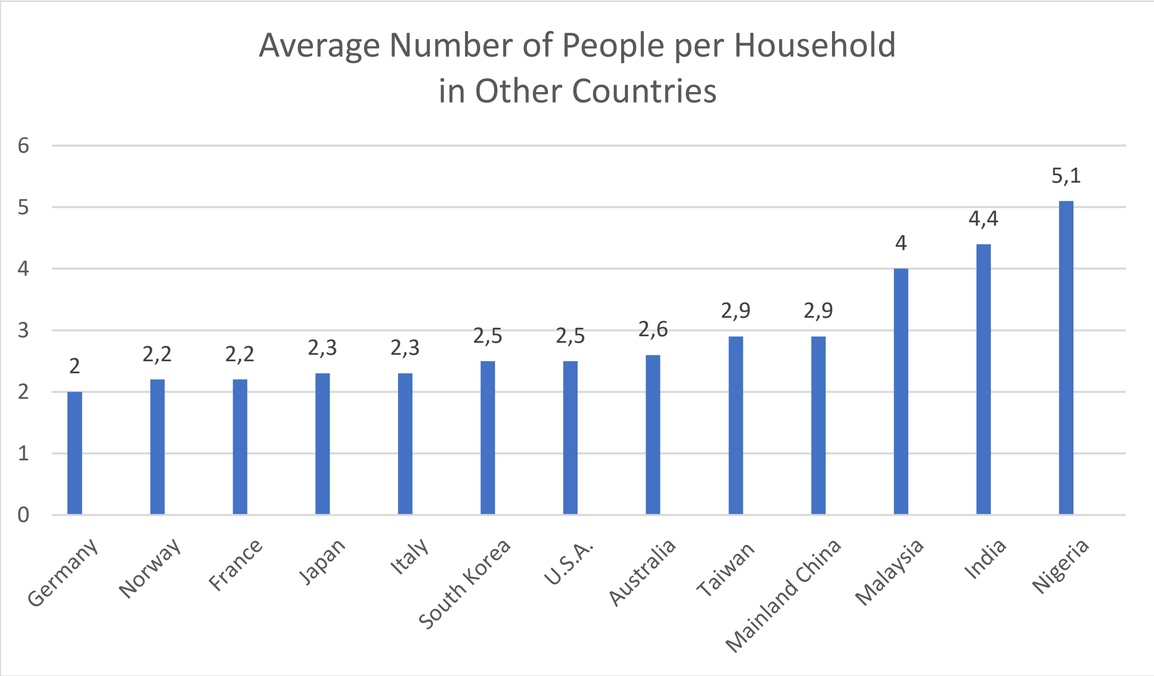
Figure 3: Average Household Size in Taiwan



(Visualisations generated by author based on Statista, 2021n.)

Compared to other countries globally, as presented in Figure 4, Taiwan is in the middle regarding the average number of people per household.

Figure 4: Average Household Size in Other Countries



(Visualisations generated by author based on Australian Institute of Family Studies, n.d.; Esri, 2021a; Esri, 2021b; Statista, 2019; Statista, 2021a; Statista, 2021c; Statista, 2021d; Statista, 2021e; Statista, 2021f; Statista, 2021n; United Nations, 2017.)

Table 4: Average Household Size in Taiwan's Largest Cities

Cities	Average Household Size (2000)
Taipei City	3.1
Taichung City	3.2
Kaohsiung City	3.1
Tainan City	3.2
National Average 2001	3.3

(Table generated by author based on National Statistics, Republic of China [Taiwan], n.d.)

Based on the numbers from 2000, no significant difference in household size existed between major cities and the average household size in the rest of Taiwan: Taipei, Taichung, Kaohsiung, and Tainan are the largest cities in Taiwan, each with a population of over one million people (see Table 4) (National Statistics, Republic of China [Taiwan], n.d.). Since no data were available for all cities, the focus in this paper is Taipei. In 2000, Taipei had an average of 3.1 people per household (see Table 4) (National Statistics, Republic of China [Taiwan], n.d.). However, Taipei's average household size declined steadily through 2020, with a resulting average household size of 2.45 people (Taipei City Government, 2020).

However, household size and tourism are important factors in crowding and the spread of SARS-CoV-2 (see Chapter 2.2.1).

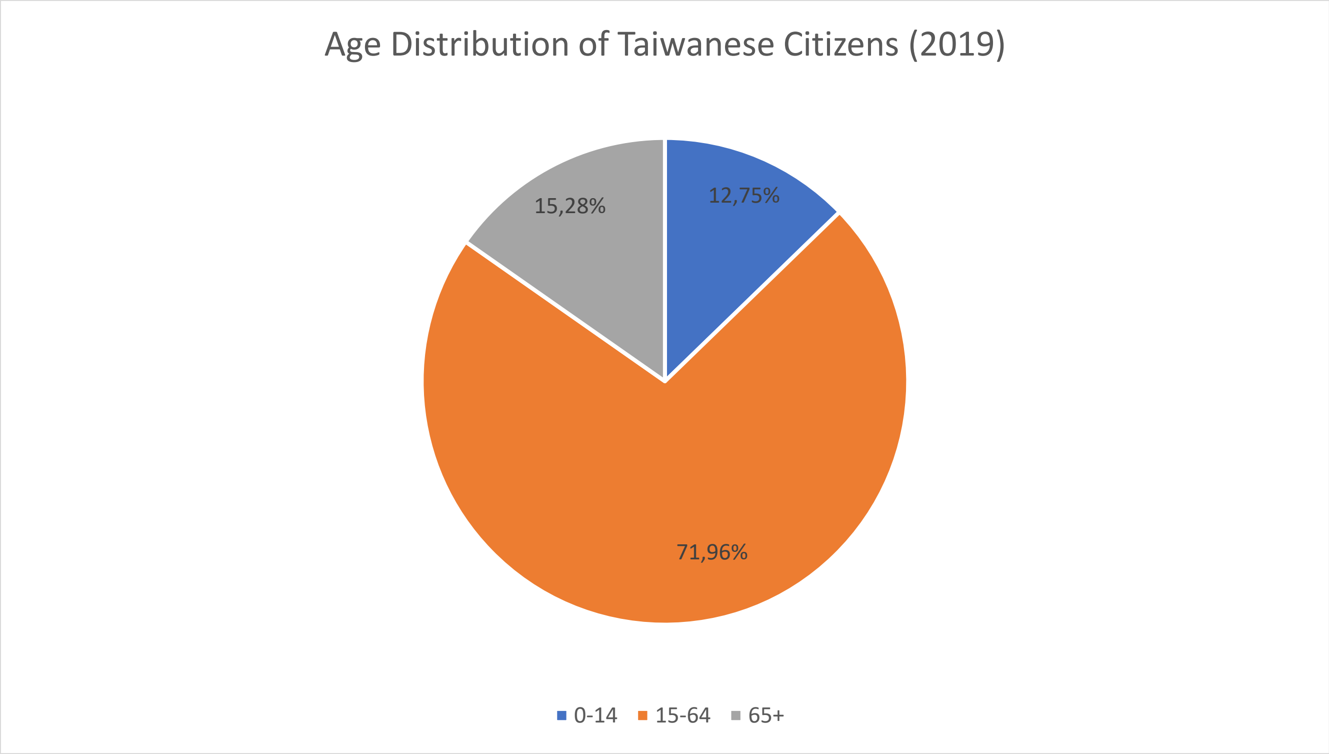
The tourism sector has been substantially affected by the COVID-19 pandemic (Tran et al., 2020; OECD, 2021, as cited in Kuo, 2021). As in many other countries worldwide, tourism decreased in Taiwan due to COVID-19 (Tran et al., 2020). During the pandemic, Taiwan experienced a smaller decrease in tourism than other countries, although the reduction has been proven in international and national tourism (Tran et al., 2020; Kuo, 2021); Tran et al. (2020) demonstrate that international tourism decreased by 0.034% per new infection in Taiwan. The implemented border closures also significantly impacted tourism in Taiwan (Tran et al., 2020). In March 2020, Taiwan's Ministry of Health and Welfare (MOHW) implemented a border closure that allowed only Taiwanese citizens to enter the island; this set the “global travel warning to Level 3” (Kuo, 20201, p. 4); this level recommended that the Taiwanese population obviate unnecessary travel activities, not receive international tourists, and not plan international travels (Kuo, 2021; Tran et al., 2020).

One of several reasons for decreased international tourism was the fear of infection, which led to a more conservative view on tourism (Kuo et al., 2021). Additionally, national tourism decreased since people were advised to remain home, work from home if possible, and reduce social activities as much as possible (Kuo, 2021). Once the Level 3 “global travel warning” (Kuo, 2021, p. 4) was implemented, people also reduced trips to tourist attractions and instead shifted, as much as possible, their lives online (Garcia et al., 2021; Itani & Hollebeek, 2021, as cited in Kuo, 2021). To reduce face-to-face contact, people replaced travelling with virtual reality tours (Garcia et al., 2021; Itani & Hollebeek, 2021, as cited in Kuo, 2021). Consequently, citizen visits to Taiwanese tourist attractions decreased by 55% (MOTC, 2021, as cited in Kuo, 2021). This reduction can be mainly explained by worries about contracting the SARS-CoV-2 virus and observing social distancing in public transportation (Kuo, 2021).

In addition to the reduced numbers of tourists, the Taiwanese government implemented restrictions affecting “crowded public outdoor areas in Taiwan, such as amusement parks, theme parks, [and] scenic spots” (Kuo, 2021, p. 4) as well as other measures to prevent further infections (Kuo, 2021).

4.1.3) Age Distribution

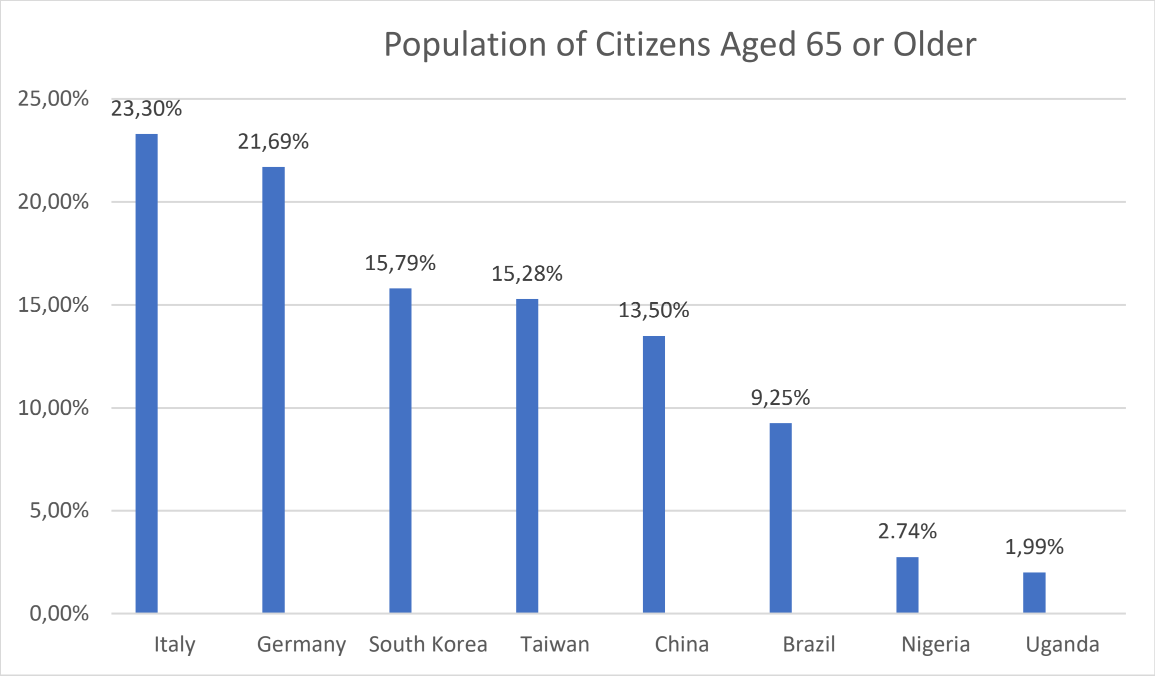
Figure 5: Age Distribution Taiwan



(Visualisations generated by author based on Statista, 2021b.)

In Taiwan, 15.28% of the population are 65 years of age or older (see figure 5) (Statista, 2021b). Comparing this with other countries, the number of people in Taiwan who are 65 or older is in the middle range (see figure 6). In 2020, 23.3% of Italy's population was 65 years of age or older; in Germany, this figure was 21.69%; in South Korea, it was 15.79%; in China, it was 13.5%; in Brazil, it was 9.25%; in Nigeria, it was 2.75%; and in Uganda, it was 1.99% (see figure 6) (Statista, 2020a; Statista, 2020b; Statista, 2020c; Statista, 2019b; Statista, 2020d; Statista, 2020e; Statista, 2020f).

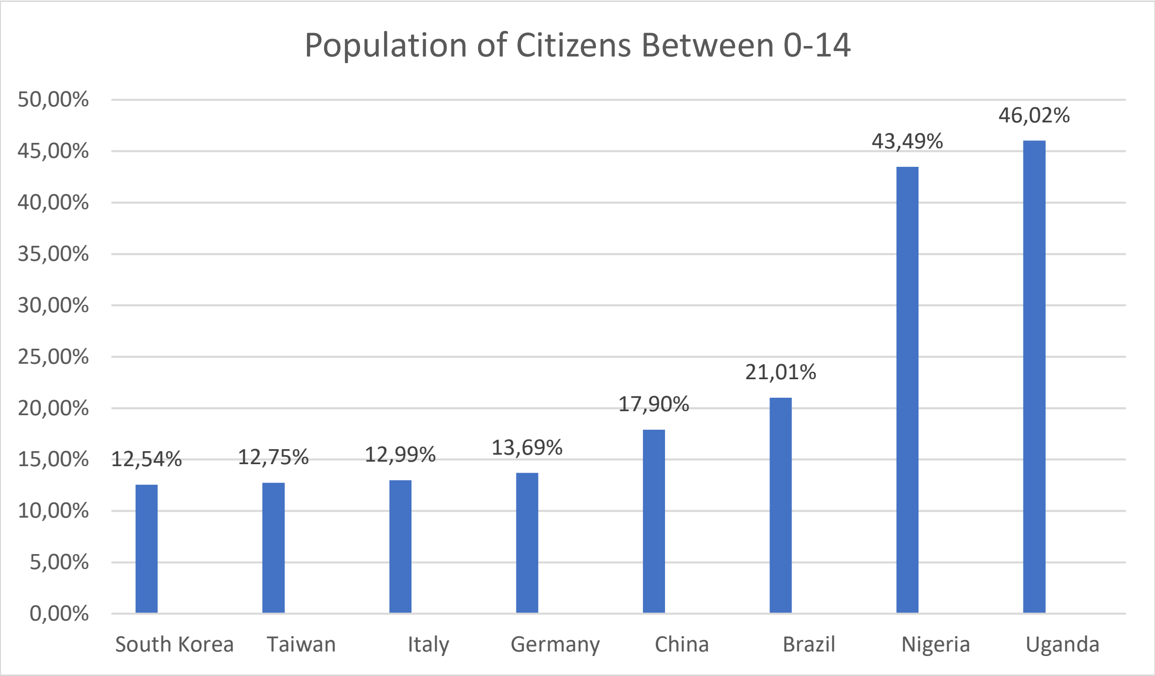
Figure 6: Population of the Elderly in Different Countries



(Visualisations generated by authir based on Statista, 2021b; Statista, 2021g; Statista, 2021h; Statista, 2021i; Statista, 2021j; Statista, 2021k; Statista, 2021l; Statista, 2021m.)

Conversely, only 12.75% of the Taiwanese population are 0–14 years of age (see figure 7), which is comparable to Italy (12.99%), Germany (13.96%), and South Korea (12.54%); however, this is a considerable difference from Nigeria, where those 0–14 comprise 43.49% of the population, and Uganda, where this figure is 46.02% (see figure 7) (Statista, 2020a; Statista, 2020b; Statista, 2020e; Statista, 2020f).

Figure 7: Population of Younger People in Different Countries



(Visualisations generated by author based on Statista, 2021b; Statista, 2021g; Statista, 2021h; Statista, 2021i; Statista, 2021j; Statista, 2021k; Statista, 2021l; Statista, 2021m.)

This age distribution indicates a medium risk for symptomatic outbreaks of COVID-19, since the elderly account for 15.28% of the Taiwanese population (Statista, 2021b). These people are more vulnerable to increased symptomatic morbidity and mortality from the virus. However, Taiwan's small population of those 0–14 could be asymptomatic, which could lower the risk of symptomatic morbidity or mortality (see figure 7). Since the Taiwanese population mainly comprises people who are 15–64 years of age, the chances of symptomatic outbreaks are high; however, the mortality rate in this age group is lower than in the elderly

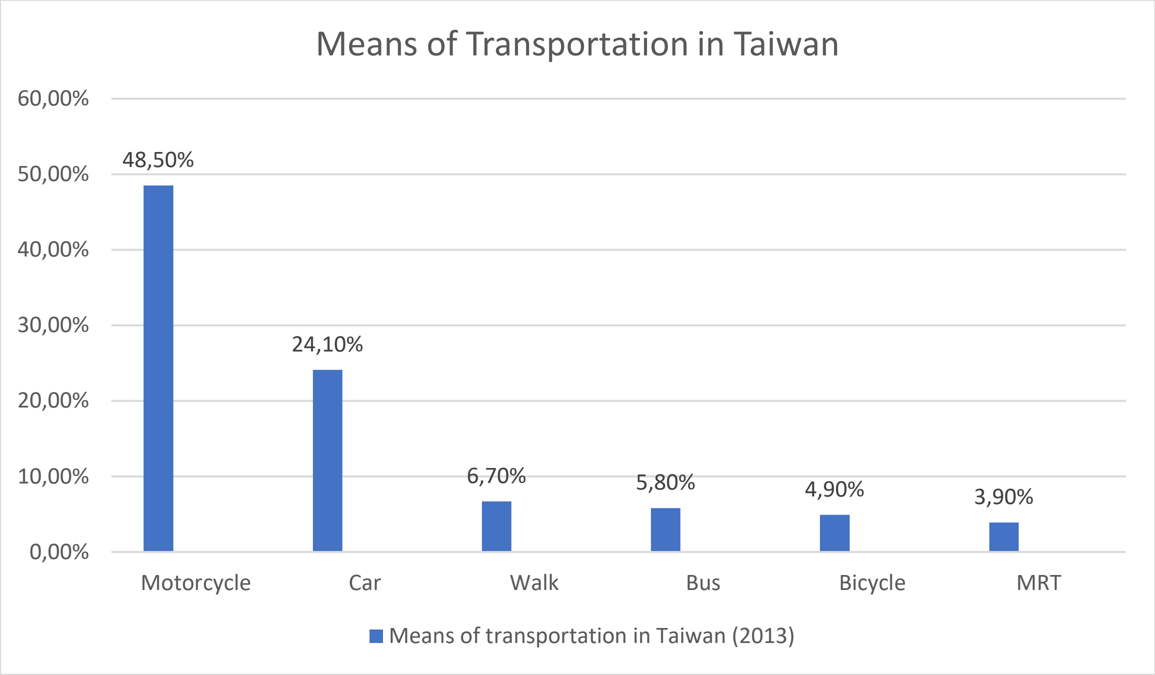
4.1.4) Intergenerational Living

Intergenerational housing in Italy led to a high infection rate among the elderly; accordingly, this factor is crucial in the dispersion of the virus in many countries. As in Italy and East Asia, intergenerational housing is common and part of the traditional Taiwanese lifestyle (Yi et al., 2006, as cited in Yang et al., 2020); three-generation households are typical (Yang et al., 2020). The transmission rate in these households is 60%, and the people who have been infected are 11–85 years of age; there have been twice as many infected males as females, and of these, two out of six have been asymptomatic (Yang et al., 2020). Thus, intergenerational living could make Taiwanese people vulnerable to unnoticed SARS-CoV-2 infections through asymptomatic younger people who could swiftly infect their elders (Yang et al., 2020). The elderly would, in this case, become infected through everyday interactions with the family, such as parents caring for the grandparents and regular visitations by the family (Yang et al., 2020). In Taiwan, the spread in families has been even higher than in health care settings (Yang et al., 2020). Furthermore, in many countries, family members caring for the elderly is connected to socioeconomic class (see Chapter 2.2.1). However, in Taiwan, this does not seem to be the case. A 2009 survey demonstrates that 68.7% of the elderly live with the family who care for them (Ministry of Foreign Affairs, Republic of China [Taiwan], 2011).

4.1.5) Means of Transportation

In Taiwan, public transportation is not popular (Shi & Yang, 2013), as people prefer to utilise private transportation. The data in Figure 8 indicate that over 70% of people utilise private transportation (Shi & Yang, 2013). Buses are the most popular means of public transportation, which includes both short- and long-distance buses (see figure 8) (Shi & Yang, 2013). While in many countries a correlation between socioeconomic classes and usage of comparative public traffic has been witnessed in Taiwan there is no visible strong connection to a lower socioeconomic class and the usage of public traffic what could be due to the low income inequality in Taiwan (Quartly, 2020).

Figure 8: Transportation Means in Taiwan



(Visualisations generated by author based on Shi & Yang, 2013.)

Furthermore, several researchers have revealed that during the COVID-19 pandemic, the usage of public transportation has fallen globally (Bucsky, 2020; Comfort, 2020, as cited in Kuo, 2021; Musselwhite et al., 2021). This phenomenon has also been observed in Taiwan (Kuo, 2021). Compared to April 2019, Taiwan's railway usage in 2020 was 36.01% lower, and usage of the High-Speed Rail was 48.09% lower (Kuo, 2021). Motorised private transportation was also reduced by 28.05% (Kuo, 2021).

One reason for this is the diminution of feeling secure in public transportation (Kuo, 2021). People have perceived an increased health risk in public transportation, such as the mass rapid transit (MRT), since maintaining recommended distances from others is challenging if the MRTs are crowded (Chang et al., 2021). In Taiwan, MRT usage has decreased by approximately 1.43% per new confirmed infection (Chang et al., 2021). Since Taiwanese citizens have attempted to avoid crowding, they have reduced usage of the MRT (Kuo, 2021). Compared to the number of passengers in January and July 2019, the 2020 usage of the Taiwanese High-Speed Rail decreased by 23.29%, the usage of the Taiwanese Railways decreased by 17.81%, and highway transportation and local street usage fell by 34.23% (MOTC, 2021, as cited in Kuo, 2021). Although Taiwan has not implemented any mandatory stay-at-home measures, some private companies have implemented these measures for their employees; this has reduced their usage of transportation (Chang et al., 2021).

Furthermore, the Central Epidemic Command Centre advised increasing the global travel warning in Taiwan to Level 3, which was implemented on 21 March 2020 (Kuo, 2021), which has also affected the usage of public transportation (Kuo, 2021). This has also affected the tourism industry since fewer people are taking holiday trips due to safety concerns (Kuo, 2021). Generally, domestic travelling has lessened in frequency and length (Kuo, 2021). Neuburger and Egger (2021) present a correlation between the perceived travel risk due to COVID-19 and the inclination not to travel or to cancel previously planned trips (Neuburger & Egger, 2021, as cited in Kuo, 2021). This has also been seen in the tourist numbers or recreational tourist areas in Taiwan that experienced a tourist decline of 53.5% in April 2020 compared to 2019 (Kuo, 2021).

As previously mentioned (see Chapter 2.2.1), air travel affects the spread of the virus; thus, it is important to know that Taiwan has international airports in Taoyuan, Kaohsiung, and Taipei. North Taiwan is the main transportation hub of the island and the region in which the majority of imported cases have been confirmed (Hsu et al., 2020b). As of 10 April 2020, Taiwan had 382 cases, 54 of which were local infections and 328 of which were imported cases (Hsu et al., 2020b); by 12 May 2020, there had been 440 cases, 55 of which were local infections and 349 of which were imported cases, which illustrates the effect of international travel.

4.1.6) Socioeconomic Status

To analyse socioeconomic factors, it is necessary to consider income inequality in Taiwan; the Gini coefficient is utilised for this purpose.

> The Gini index measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution. The Gini index measures the area between the Lorenz curve and the hypothetical line of absolute equality, expressed as a percentage of the maximum area under the line. A Gini index of zero represents perfect equality and 100, perfect inequality. (OECD, 2006)

Countries with a lower Gini coefficient have had fewer COVID-19 cases than those with a higher Gini coefficient (Quartly, 2020). Several economists see a correlation between Taiwan's low Gini coefficient and their successful fight against the virus (Quartly, 2020). In

2020, Taiwan's Gini coefficient was 34% or 0.34 points on a scale from 0–1 (Statista, 2021o), which is lower than those of Norway or Denmark (Quartly, 2020). This is because, with the exception of a few 'mega-earners' (the 1%) (Quartly, 2020), Taiwan comprises entrepreneurs and many small businesses (Quartly, 2020).
Taiwan generally has low labour income inequality, which is visible when considering that the majority of wages do not indicate a significant gap but are somewhat similar (Quartly, 2020). Consequently, it can also be assumed that the socioeconomic gap between families is not large. This theory is supported by the fact that socioeconomic classes affect the infection rate, as seen in Chapter 2.2.1, and that countries with lower income inequality or Gini coefficients were less affected during the COVID-19 pandemic (Quartly, 2020). Furthermore, since testing frequency is connected to socioeconomic status, it can be assumed that the majority of Taiwanese citizens have the same testing frequency since there is no vast income gap between the majority of people.

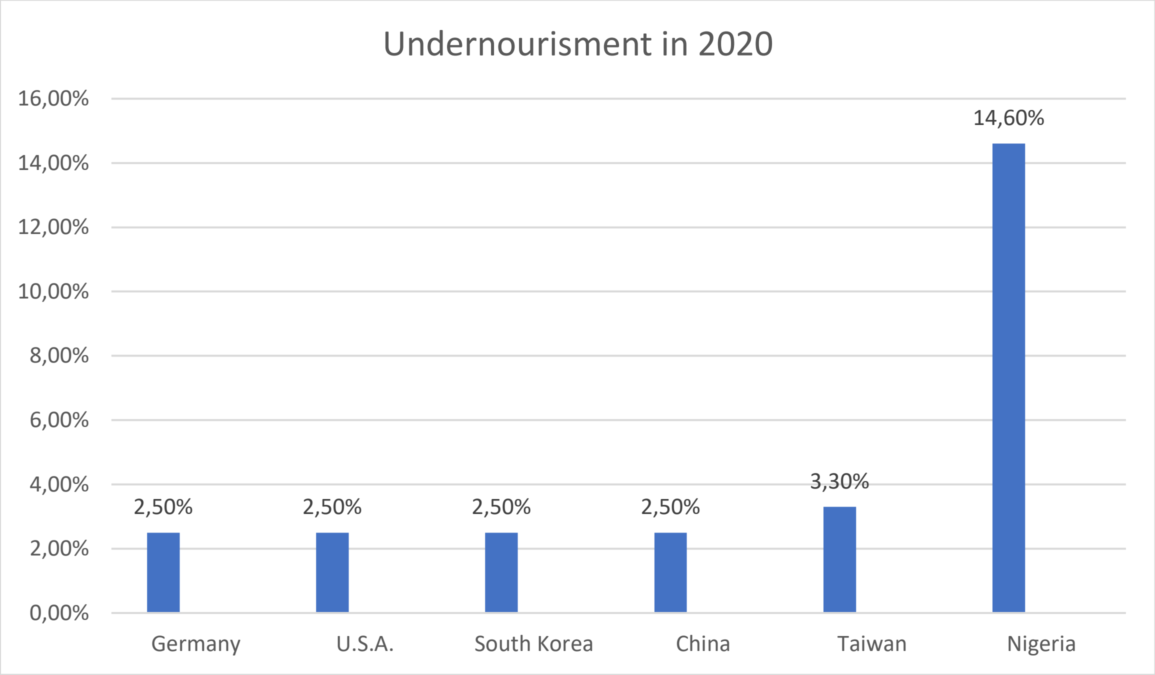
In addition to testing, the workplace is important; while some can work from home, those in the manufacturing and medical industries, for example, cannot do so. As mentioned before, this could lead to an inequality in infection rates. However, the majority of companies have not allowed their employees to work from home; since the government has not implemented a lockdown (Wei, 2021). Examining the socioeconomic factors offered in Chapter 2.2.1, which state that people from lower income classes make more use of public transport, it appears that this does not apply to Taiwan.

4.1.7) Medical Care

Taiwan's medical care system is based on the “government-run, single-payer National Health Insurance (NHI), a universal health coverage scheme” (Cheng, 2015) that offers health care to Taiwan's citizens and foreign inhabitants and is inexpensive and easy to access (Cheng, 2015; Wu et al., 2015). The NHI covers more than 99% of all citizens in Taiwan (Chiang et al., 2020; Lin et al., 2020c). Every NHI card is “linked to thousands of pharmacies and hundreds of local health centres nationwide” (Lin et al., 2020a, p. 1510). Furthermore it covers a wide range of medical benefits, including outpatient visits, inpatient care, dental care, traditional Chinese medicine, renal dialysis, and prescriptions (Cheng, 2015). Additionally, it offers unique benefits for people in lower socioeconomic classes, such as those living in inaccessible regions in the mountains or on islands (Cheng, 2015). NHI provides the same treatment regardless of one's income or wealth (Cheng, 2015). Consequently, accessing medical care has no financial barriers (Cheng, 2015). Phoebe Chi, the CEO of the Taiwan Association of Cancer Patients, commented regarding Taiwanese health care: “We go to the hospital like it's the shopping mall” (Emanuel, 2020, p. 321). This view exists because patients can visit any doctor or hospital in Taiwan and request blood tests and MRIs, and NHI pays for the services (Emanuel, 2020). Generally, through NHI, the majority of people are healthy since they have free access to universal health care. As mentioned in Chapter 2.2.1, one factor that could lead to a more severe COVID-19 outbreak is the health system's capacity for intensive care treatment. Taiwan is prepared for health emergencies: the nation has 1,100 beds in negative pressure isolation rooms and 21,000 beds in isolation rooms (Lin et al., 2020a). Furthermore all health workers questioned in the interviews stated that their work space has enough PPE for emergencies and that the majority of them received special training for health emergencies which led them to believe that the Taiwanese health sector is well prepared in the case of a health emergency.

Since undernourishment can be related to non-communicable comorbid conditions that affect vulnerability to SARS-CoV-2, one must analyse undernourishment in Taiwan and consider it from a global perspective. In 2020, 3.3% of all people in Taiwan suffered undernourishment (Knoema, 2021e). Compared to the US (2.5%) (Knoema, 2021f), Germany (2.5%) (Knoema, 2021b), South Korea (2.5%) (Knoema, 2021d), Mainland China (2.5%) (Knoema, 2021a), and Nigeria (14.6%) (Knoema, 2021c), Taiwan's general level of undernourishment is slightly higher than in other developed countries (see figure 9). However, compared to developing countries, it is significantly lower.

Figure 9: Undernourishment in Different Countries in 2020



(Visualisations generated by author based on Knoema, 2021a; Knoema, 2021b; Knoema, 2021c; Knoema, 2021d; Knoema, 2021e; Knoema, 2021f.)

4.2) Taiwan's Meteorological Factors

In this chapter meteorological factors will be analysed based on the gathered data presented in the literature review and data that collected from scientific and governmental sources through literature about Taiwan. This data will be compared to other countries to put it in a global context. Since Taiwan has two climates and Hsu et al (2020b) argue these two climates show a significant difference in the spread of SARS-CoV-2. The solar radiation, humidity, temperature and wind speed of Taipei and Tainan will be analysed to see if there is a significant climatic difference between north and south Taiwan. Taipei will be used to measure the climate of north Taiwan and Tainan will be used to measure the climate of south Taiwan. Since the air pollution is independent from the climate national data will be used in the analysis.

4.2.1) Solar Radiation

To understand Taiwan's climate, it is essential to view it in a global context to realise whether its data are on a lower, comparable, or higher spectrum than other countries.

Brazil (São Paulo)

Table 5: Solar Radiation in São Paulo

Month	Total Sun Hours
January	170
February	160
March	165
April	165
May	180
June	175
July	185
August	175
September	155
October	155
November	165
December	150
Yearly Total	2,955

(Table generated by author based on Climates to Travel, n.d.-b)

Vietnam (Ho Chi Minh)

Table 6: Solar Radiation in Ho Chi Minh

Month	Total Sun Hours
January	245
February	245
March	270
April	240
May	195
June	170
July	180
August	170
September	160
October	180
November	200
December	225
Yearly Total	2,490

(Table generated by autor based on Climates to Travel, n.d.-f)

Italy (Milan)

Table 7: Solar Radiation in Milan

Month	Total Sun Hours
January	60
February	95
March	150
April	175
May	210
June	245
July	285
August	250
September	185
October	130
November	65
December	60
Yearly Total	1,915

(Table generated by author based on Climates to Travel, n.d.-c)

Nigeria (Lagos)

Table 8: Solar Radiation in Lagos

Month	Total Sun Hours
January	165
February	170
March	175
April	180
May	175
June	115
July	100
August	110
September	115
October	165
November	185
December	190
Yearly Total	1,845

(Table generated by author based on Climates to Travel, n.d.-d)

Norway (Oslo)

Table 9: Solar Radiation in Oslo

Month	Total Sun Hours
January	40
February	75
March	125
April	180
May	220
June	250
July	245
August	215
September	145
October	85
November	50
December	35
Yearly Total	1,670

(Table generated by author based on Climates to Travel, n.d.-e)

Taiwan (Taipei)

Table 10: Solar Radiation in Taipei

Month	Total Sun Hours
January	80
February	70
March	90
April	95
May	115
June	120
July	180
August	190
September	115
October	125
November	100
December	90
Yearly Total	1,405

(Table generated by author based on Climates to Travel, n.d.-a)

Taiwan (Tainan)

Table 11: Solar Radiation in Tainan

Month	Total Sun Hours
January	180
February	160
March	180
April	175
May	185
June	180
July	210
August	190
September	180
October	195
November	175
December	175
Yearly Total	2,180

(Table generated by author based on Climates to Travel, n.d.-a)

As presented in Tables 5–11, Taipei has fewer total sun hours than Oslo, Milan, Ho Chi Minh, Lagos, and São Paulo, while Tainan has fewer total sun hours than only São Paulo and Ho Chi Minh, but more total sun hours than Lagos, Milan, and Oslo (Climates to Travel, n.d.-a; Climates to Travel, n.d.-b; Climates to Travel, n.d.-c; Climates to Travel, n.d.-d; Climates to Travel, n.d.-e; Climates to Travel, n.d.-f).

However, especially in Milan and Oslo, the distribution of total sun hours is not equal across the year (see table 7 & table 9) (Climates to Travel, n.d.-c; Climates to Travel, n.d.-e). These cities feature significant differences between colder and warmer seasons. Warmer seasons have more sun hours than colder seasons; Milan exhibits the most significant difference with only 60 sun hours per month in December and January, while in July, the city experiences 285 sun hours; this is a difference of 225 sun hours between the darkest and sunniest months (see table 7) (Climates to Travel, n.d.-c). In Oslo, the darkest month is December, with only 35 sun hours, while the people in this city experience 250 sun hours in June; this is a difference of

215 sun hours between the darkest and sunniest months (see table 9) (Climates to Travel, n.d.-e).

Conversely, the cities with the least difference in sun hours are Lagos and São Paulo (see table 5 & 8) (Climates to Travel, n.d.-b; Climates to Travel, n.d.-d). São Paulo has its highest number of sun hours in July with 185 sun hours, while December has the least with 150 sun hours; this is a difference of 25 sun hours (see table 5) (Climates to Travel, n.d.-b). In Lagos, December has the most sun hours—190—while July has only 100 sun hours and is the darkest month in Lagos; this is a difference of 90 sun hours (see table 8) (Climates to Travel, n.d.-d).

Ho Chi Minh enjoys 270 sun hours in March, making it the sunniest month of the year, while September is the darkest month with 160 sun hours, resulting in a difference of 110 sun hours (see table 6) (Climates to Travel, n.d.-f). Taipei's sunniest month is August with 190 sun hours; the darkest is February with 70 sun hours, which is a difference of 120 sun hours, whereas Tainan's sunniest month is July with 210 sun hours; its darkest month is February with 160 sun hours, which is a difference of 50 sun hours (see table 10 & 11) (Climates to Travel, n.d.-a).

Compared to Oslo and Milan, Taipei and Tainan experience a weaker seasonal influence, meaning that the difference of sun hours in different seasons is reduced, although Taipei presents a stronger seasonal influence in solar radiation than Tainan (see table 7, 9-11). Lagos and São Paulo feature minor differences and equal distribution of sun hours, whereas Oslo and Milan's sun hours fluctuate frequently (see table 5, 7-9). Taipei and Tainan's sun hours fall between the Lagos, São Paulo and Milan and Oslo (see table 5, 7-11). While Oslo has only 35 sun hours in December (see figure 7) (Climates to Travel, n.d.-e), Taipei does not experience a number this low in any month (see figure 8) (Climates to Travel, n.d.-a). With its 60 sun hours in December and January (Climates to Travel, n.d.-c), Milan's sun hours are fewer than Taipei's 70 sun hours in February (see figure 5 & 8) (Climates to Travel, n.d.-a). While Taipei is similar to Milan in its darkest month, Tainan portrays a different picture. Tainan has 160 sun hours in its darkest month (Climates to Travel, n.d.-a), which is more sun hours than São Paulo, Lagos, Milan, Oslo, and Taipei; additionally, it has as many sun hours in its darkest month of the year as Ho Chi Minh (see figure 3-9) (Climates to Travel, n.d.-a; Climates to Travel, n.d.-b; Climates to Travel, n.d.-c; Climates to Travel, n.d.-d; Climates to Travel, n.d.-e; Climates to Travel, n.d.-f).

A slight difference occurs between the sunniest and darkest months in Taipei and Tainan, and both experience only a medium fluctuation in sun hours due to seasons; however, the two cities experience a difference between their sun hours in their darkest months (see table 10 & 11) (Climates to Travel, n.d.-a). In its darkest month, Tainan experiences more sun than Taipei (see table 10 & 11) (Climates to Travel, n.d.-a).

As mentioned, Taipei's darkest month features sun hours that are closer to those of Milan (see table 7 & 10). This can produce the argument that people could suffer vitamin D deficiencies, especially in colder seasons (see Chapter 2.2.2), which could make the citizens of Taipei more prone to SARS-CoV-2 infections. Furthermore, as mentioned in Chapter 2.2.2, the SARS-CoV-2 virus is less stable in high UV radiation environments; this could benefit Tainan but result in a disadvantage for Taipei.

4.2.2) Temperature

Brazil (São Paulo) Average Temperature

Table 12: Temperature in São Paulo

Month	Min. (° C)	Max. (° C)	Mean (° C)
January	20	29	24.2
February	20	29	24.5
March	19	28	23.7
April	18	26	22.2
May	15	24	19.5
June	14	23	18.7
July	13	23	18.3
August	14	25	19.2
September	15	26	20.3
October	17	27	21.6
November	17	27	22.1
December	19	28	23.6
Yearly Average	16.8	26.1	21.45

(Table generated by author based on Climates to Travel, n.d.-b)

Vietnam (Ho Chi Minh) Average Temperature

Table 13: Temperature in Ho Chi Minh

Month	Min. (° C)	Max. (° C)	Mean (° C)
January	21	32	26.5
February	23	33	28
March	24	34	29
April	26	35	30.5
May	25	34	29.5
June	25	32	28.5
July	24	32	28
August	24	32	28
September	24	31	27.5
October	24	31	27.5
November	23	31	27
December	21	31	26
Yearly Average	23.7	32.3	27.95

(Table generated by Nadja Meichle based on Climates to Travel, n.d.-f)

Italy (Milan) Average Temperature

Table 14: Temperature in Milan

Month	Min (° C)	Max (° C)	Mean (° C)
January	-1	6	2.9
February	0	9	4.9
March	4	15	9.6
April	8	18	13.1
May	13	24	18.2
June	17	27	22.1
July	19	30	24.6
August	18	29	24
September	15	25	19.8
October	10	19	14.5
November	5	12	8.2
December	1	7	3.7
Yearly Average	9.2	18.5	13.85

(Table generated by author based on Climates to Travel, n.d.-c)

Nigeria (Lagos) Average Temperature

Table 15: Temperature in Lagos

Month	Min. (° C)	Max. (° C)	Mean (° C)
January	23	34	28.3
February	25	34	29.3
March	26	34	29.7
April	25	33	29.2
May	24	32	28.1
June	24	30	26.8
July	23	29	26.1
August	23	29	26
September	23	29	26.4
October	23	31	27
November	24	33	28.4
December	24	34	28.6
Yearly Average	23.9	31.7	27.75

(Table generated by author based on Climates to Travel, n.d.-d)

Norway (Oslo) Average Temperature

Table 16: Temperature in Oslo

Month	Min (° C)	Max (° C)	Mean (° C)
January	-5	0	-2.8
February	-5	0	-2.4
March	-2	4	1
April	2	10	5.9
May	7	16	11.6
June	11	20	15.3
July	13	22	17.6
August	12	21	16.5
September	8	16	11.8
October	4	9	6.6
November	-1	4	1.6
December	-5	0	-2.4
Yearly Average	3.2	10.3	6.75

(Table generated by author based on Climates to Travel, n.d.-e)

Taiwan (Taipei) Average Temperature

Table 17: Temperature in Taipei

Month	Min. (° C)	Max. (° C)	Mean (° C)
January	14	18	16.2
February	14	19	16.6
March	16	21	18.7
April	20	25	22.2
May	23	28	25.5
June	25	31	28
July	27	33	30
August	26	33	29.7
September	25	30	27.7
October	23	27	24.8
November	20	24	21.6
December	16	20	18
Yearly Average	20.7	25.9	23.25

(Table generated by author based on Climates to Travel, n.d.-a)

Taiwan (Tainan) Average Temperature

Table 18: Temperature in Tainan

Month	Min. (° C)	Max. (° C)	Mean (° C)
January	14	23	18.5
February	15	24	19.4
March	18	26	22
April	21	29	25.2
May	24	31	27.7
June	26	32	28.9
July	26	33	29.6
August	26	32	29.2
September	25	32	28.6
October	23	31	28.8
November	20	28	23.6
December	16	24	19.8
Yearly Average	21.2	28.8	24.95

(Table generated by author based on Climates to Travel, n.d.-a)

As mentioned previously, COVID-19 cases have been high in regions where the annual mean temperature is 3° C–17° C and the virus is most stable at 4° C. Comprehensively examining the numbers in Tables 12–18 reveals that only Oslo and Milan (Climates to Travel, n.d.-c; Climates to Travel, n.d.-e) belong to this category. According to Araujo and Naimi (2020), 95% of all global SARS-CoV-2 infections have occurred in areas where temperatures are 2° C–10° C. Only Milan (Climates to Travel, n.d.-c) falls into that category, while São Paulo, Lagos, Ho Chi Minh, Taipei, and Tainan have a minimum temperature of over 10° C in their coldest months (Climates to Travel, n.d.-a; Climates to Travel, n.d.-b; Climates to Travel, n.d.-f).

A slight difference occurs between the mean minimum temperature in Taipei (20.7° C) and Tainan (21.2° C) as does a slight difference between the mean annual temperature in Taipei (23.25° C) and Tainan (24.95° C) (Climates to Travel, n.d.-a). Since the temperature difference is minor, it can be concluded that for SARS-CoV-2 infections, no significant difference exists between the cities. Neither Taipei nor Tainan reach 4° C on their coldest days; therefore, they do not achieve the temperature at which the virus is most stable.

Islam et al. (2020) argue that the relative risk of transmission decreases when the maximum temperature is higher than 27° C. Tainan’s average temperature does not fulfil this criterion in four months of the year; however, this occurs in Taipei in six of 12 months. No months experience minimum temperatures between 2° C and 10° C, and the annual mean temperatures of Taipei and Tainan are above 3° C–17° C. This demonstrates a more beneficial environment for fighting the SARS-CoV-2 virus in Tainan compared to Taipei as well as cities like São Paulo, Milan and Oslo.

Seasons influence the spread of SARS-CoV-2 due to low temperatures, low UV radiation, and typical behaviour of adapting to colder weather; consequently, one must analyse whether Taipei and Tainan experience this seasonal effect. Taipei's minimum temperature ranges from 14° C–27° C, and its average temperature ranges from 16.2° C–30° C, whereas Tainan's minimum temperature ranges from 14° C–26° C, and its average temperature ranges from 18.5° C–29.6° C; both cities exhibit a seasonal temperature difference (Climates to Travel, n.d.-a) that could slightly affect the cases, although, as stated previously, even the lowest temperatures do not fall into the categories in which the virus is most stable. The temperature change in colder seasons is significantly smaller than in Milan and Oslo, where immune systems are compromised due to the colder weather. Furthermore, crowding indoors due to low temperatures in colder seasons is less likely in Taipei and Tainan than in Milan and Oslo, since the temperature difference between the lowest temperatures in these latter cities is large. Consequently, the temperature change in Taipei and Tainan has a limited effect on indoor crowding behaviour.

4.2.3) Humidity

Taipei

Table 19: Humidity in Taipei

Month	RH Percentage
January	82%
February	84%
March	83%
April	84%
May	85%
June	86%
July	84%
August	84%
September	85%
October	84%
November	84%
December	81%
Yearly Average	83%

(Table generated by author based on ClimaTemps.com, n.d.-b)

Tainan

Table 20: Humidity in Tainan

Month	RH Percentage
January	77%
February	78%
March	78%
April	81%
May	83%
June	84%
July	84%
August	86%
September	84%
October	81%
November	80%
December	77%
Yearly Average	81%

(Table generated by author based on Climate-data.org, n.d.)

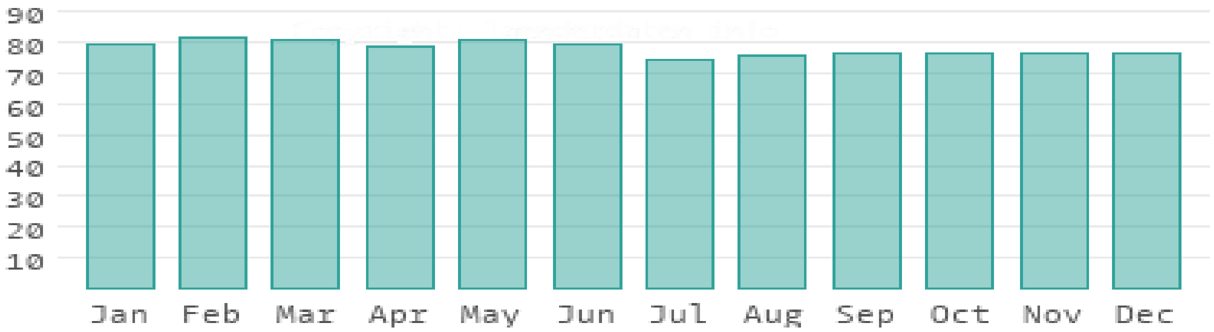
To understand the RH in Taiwan and the difference between the northern and southern areas of the island, the RHs of Taipei (northern) and Tainan (southern) are analysed. As presented in Tables 19 and 20, both cities have high humidity throughout the year (ClimaTemps.com, n.d.-b; Climate-data.org, n.d.). Taipei's annual humidity percentage is 83%, which is higher than Tainan's 81%, although the difference is negligible (ClimaTemps.com, n.d.-b; Climate-data.org, n.d.). Slight seasonal differences are seen in the winter months; however, they do not seem to be significant compared to Oslo, which features a 17% difference between the maximum and minimum RH (81% and 64%, respectively) (Climatemps.com, n.d.-a). The difference between Taipei's maximum (86%) and minimum (81%) RH is 5% (ClimaTemps.com, n.d.-b), while Tainan's maximum RH is 86% and its minimum RH is 77%, which is a 9% difference (Climate-data.org, n.d.).

Tainan and Taipei's RHs are generally high every month (ClimaTemps.com, n.d.-b.; Climate-data.org, n.d.). Consequently, the SARS-CoV-2 virus is likely to settle to the ground more quickly compared to countries with low humidity; thus, droplets in Taiwan remain in the air for a shorter time, with which the chance of becoming infected with SARS-CoV-2 decreases (see Chapter 2.2.2). If the SARS-CoV-2 virus behaves similar to the MERS virus, then 70% RH should be sufficient to disaggregate the virus more rapidly (see Chapter 2.2.2). Sarkodie and Owusu (2020) demonstrate that high RH reduces lifespan of the virus and its transmission, which would be favourable for Taiwan due to its high RH.

Since it was not possible to locate disaggregated data for Tainan, the data for Taipei are utilised.

Figure 10: RH in Taipei

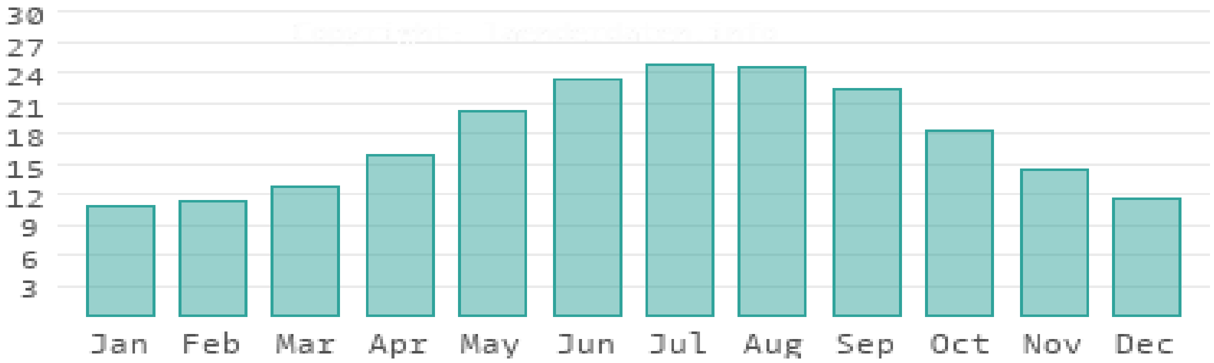
RH Percentages



(Worlddata.info, n.d.).

Figure 11: AH in Taipei

AH in g/m³ (approx.)



(Worlddata.info, n.d.).

Taipei's RH is equally distributed over the year, while its AH reveals a seasonal difference (Worlddata.info, n.d.). Especially in the summer months, the AH is high, while it is at its lowest in the winter months. For example, in July, the AH achieves slightly more than 24 g/m^3, while in December, January, and February, the AH remains under 12 g/m^3 (Worlddata.info, n.d.).

AH has a significant seasonal effect on COVID-19 infection rates since the winter months experience lower humidity than the summer months. Since Taiwan also experiences lower humidity in the colder months, it is logical that in these months, the chance of infection with the SARS-CoV-2 virus is increased (Worlddata.info, n.d.).

4.2.4) Wind Speed

Taipei

Table 21: Wind Speed in Taipei

Month	Average Wind Speed 2020–2021
January	14 km/h
February	12 km/h
March	10.4 km/h
April	13.7 km/h
May	6.6 km/h
June	8 km/h
July	9 km/h
August	5.4 km/h
September	8.7 km/h
October	17 km/h
November	18.1 km/h
December	14.5 km/h
Yearly Average	11.45 km/h

(Table generated by author based on World Weather Online, n.d.-b.)

Tainan

Table 22: Wind Speed in Tainan

Month	Average Wind Speed 2020–2021
January	15.6 km/h
February	12.6 km/h
March	12.5 km/h
April	11.8 km/h
May	12.3 km/h
June	11.7 km/h
July	13.7 km/h
August	12 km/h
September	9.7 km/h
October	12.5 km/h
November	11.6 km/h
December	17.1 km/h
Yearly Average	12.76 km/h

(Table generated by author based on World Weather Online, n.d.-a.)

A higher wind speed threatens to transport droplets containing the SARS-CoV-2 virus from the infected person over several metres to a potential host. The numbers above indicate that the wind speeds in Taipei and Tainan are relatively low (World Weather Online, n.d.-a; World Weather Online, n.d.-b). Although aerosols can spread a distance of six metres at a wind speed of between 1.1 m/s (3.96 km/h) and 4.2 m/s (15.12 km/h) (Dbouk & Drikakis, 2020, as cited in Li et al., 2020), the risk of increased infection is significantly higher when the wind is over 21 km/h. The wind speeds in Taipei and Tainan do not come near a wind speed of 21 km/h in any month (World Weather Online, n.d.-a World Weather Online, n.d.-b).

However, some droplet transportation occurs, since the wind speed is above 3.96 km/h. The spread of SARS-CoV-2 through the wind relies not only on wind speed but also on population density and RH. A higher population density may imply that additional numbers of infected people spread infectious droplets in a smaller space; however, there are also more potential hosts for the virus in a smaller space. Taipei and Tainan's wind speeds are relatively low, so the chances of wind speed being a key factor in the spread of COVID-19 is low. Nevertheless, Taiwan's high population density indicates the potential for more people to spread more droplets. Due to the limited space, the chance of infection is higher; however, since Taiwan's RH is high throughout the year, the droplets settle quickly and do not linger in the air.

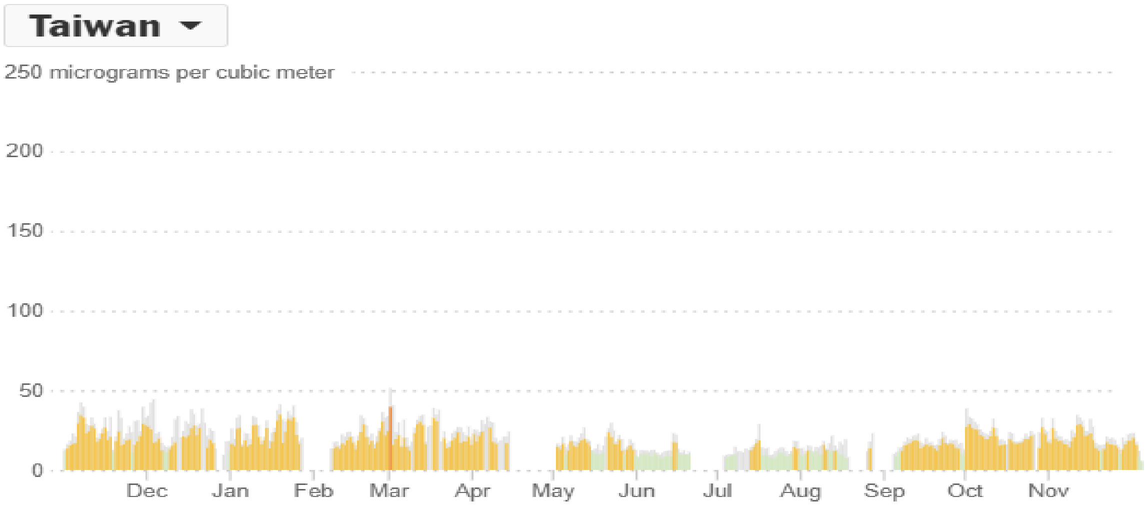
4.2.5) Air Pollution

Figure 13 displays Taiwan's 2019 PM2.5 air pollution levels as well as those Vietnam, Italy and Norway for comparison. Taiwan has lower PM2.5 air pollution than Vietnam and higher PM2.5 air pollution Italy and Norway (Popovich, 2020); however, the International Association for Medical Assistance to Travellers (2020) categorises Taiwan's PM2.5 levels as 'moderately unsafe' (IAMAT, 2020) because of its average PM2.5 of 18 $\mu g/m^3$ in 2020, which exceeded the recommended level of 10 $\mu g/m^3$ (IAMAT, 2020). Consequently, Taiwan's air pollution level poses a minor but present health threat, leading to short- and long-term illnesses. Furthermore, it presents a threat of infection and severe cases of COVID-19 for those with pre-existing respiratory conditions as well as those with weakened immune systems due to inhalation of PM2.5. Moreover, one must consider the increased risk of the SARS-CoV-2 virus particles attaching to the PM2.5 particles in the air, which further increases the chance of infection. However, since the PM2.5 level is categorised only as moderately unsafe (IAMAT, 2020), it can be concluded that the effect of Taiwan's PM2.5 level in the spread of the SARS-CoV-2 virus is relatively low compared to countries such as India, which has a high PM2.5 level.

Figure 12: PM2.5 Levels in Different Countries

(Popovich, 2020.)

Figure 13: PM2.5 Levels in Taiwan



(Popovich, 2020.)

Shen et al. (2018) collected data from January 2006 to January 2013 at 17 air monitoring stations. This data shows a seasonal difference: in summer, the PM2.5 level is with 7.3 µg/m^3 the lowest, and in winter, it is the with 14.45 µg/m^3 the highest (Shen et al., 2018).

In addition to PM2.5, PM10 has a role in SARS-CoV-2 infections since it can transport and sustain the virus in the air for a longer time. Long- and short-term exposure can lead to those with pre-existing conditions and weakened immune systems experiencing increased risk of severe infection with SARS-CoV-2 (see Chapter 2.2.2). According to Hsieh et al. (2020b) the mean PM10 concentration from 2004-2013 was 59.3 µg/m^3. PM10 levels higher than 50 µg/m^3 are significant in increased infection rates (Coccia, 2020, as cited in Maleki et al., 2021). Taiwan's mean air quality in 2004–2013 exceeded the limit of 50 µg/m^3 (Hsieh et al., 2020b). Therefore, although the PM10 level is less than 10 µg/m^3 over the limit (Environmental Protection Administration, n.d.; Hsieh et al., 2020b), it poses an increased SARS-CoV-2 infection risk.

Taiwan's average NO_2 level in 2004–2013 was 21 parts per billion (Hsieh et al., 2020b); based on the Air Quality Index of the Environmental Protection Administration (n.d.), it falls in the category of good air quality (0–30 parts per billion) (Environmental Protection Administration, n.d.), meaning that Taiwan's NO_2 level is low. Consequently, Taiwan's present NO_2 poses little or no threat to residents. Additionally, the double-hit hypothesis (see Chapter 2.2.2) is rejected since PM2.5 levels are only moderately high and NO_2 levels are low.

4.3) Taiwan's Sociocultural Factors

In this chapter the socio-cultural factors will be analysed based on the gathered data presented in the literature review and data that collected from scientific and governmental sources through literature about Taiwan. Furthermore, the data of the conducted semi-structured interviews will be used to gain a deeper understanding of the socio-cultural factors in Taiwan that affect the spread of the virus or underline already existing theories.

4.3.1) Mask Usage

During COVID-19, the global usage of face masks has been a significant factor in controlling the spread of the virus (WHO, 2020). In Western countries, the stigma of mask usage has been somewhat negative (Su & Han, 2020), and many have protested wearing masks (Philipose, 2020); however, in Taiwan, this perception has not been a factor, and masks have been one of the nation's most important factors in the fight against COVID-19 (Su & Han).

As in other East Asian countries, in Taiwan, masks are worn for many reasons (Su & Han, 2020; Lin et al., 2020a), this got confirmed by the conducted interviews. When the interviewees were questioned, the majority stated that mask wearing was popular in Taiwan before the pandemic. The interviewees mentioned several reasons for this; on the one hand, masks are worn to protect against air pollution or pollen, to maintain anonymity, and to prevent interactions with people. On the other hand, people wear them when they feel sick in order to protect others. Specifically, wearing a face mask when one feels sick seems to be polite social etiquette. When the interviewees were asked whether they support mask wearing during the pandemic, all agreed. Additionally, although some interviewees mentioned that the masks are uncomfortable for some people, they still consider masks to be necessary. Furthermore, they all agreed that especially indoors and at crowded outdoor places, face masks should be worn to protect others and themselves.

Generally, the respondents agreed that when leaving the house, a mask should be worn and that it is acceptable to remove the mask only when playing sports, eating, or drinking or when far from the city and nobody else is near. When asked why it is more common to wear a mask in Taiwan compared to other countries, the majority answered that the experience with the SARS pandemic in 2002/2003 made people, especially those from Mainland China, more aware and frightened about unknown diseases. Therefore, the Taiwanese have established measures for situations similar to SARS. A few interviewees also mentioned that Taiwanese citizens become accustomed to wearing masks early: in Taiwanese kindergartens, children are taught how to utilise a mask properly and why it is useful. Consequently, the reluctance to wear a mask is lower than in other countries. Finally, the majority of interviewees said that they also wear a mask because the government compel them to do so and that they trust the government to know that it is necessary and helpful against the virus.

4.3.2) Trust in the Government

One significant factor in citizens following implemented governmental measures is trust in the government (Han et al., 2020). These measures include, among other things, mask wearing, social distancing, quarantining, or logging in for tracking when entering public places. In 2019, Taiwanese citizens rated themselves 2.5 on a scale of 1–4 when asked about their confidence in their national government (1 being the highest level) (EVS/WVS, 2021, as cited in Meichle & Torres Lajo, 2021). Consequently, it can be said that, in 2019, Taiwanese citizens had a middle level of trust in their national authorities.

However, when asked about the government's responsibility, Taiwanese citizens answered that the government share responsibility with citizens, and each should play their part. This was also seen in the World Values Survey results: the population scored 5.5 out of 10 points, where 10 means that the "government should take more responsibility" (EVS/WVS, 2021, as cited in Meichle & Torres Lajo, 2021, p. 9). This result was evidenced during the pandemic when the government informed people and implemented measures and citizens followed these measures (Meichle & Torres Lajo, 2021).

Based on the interviews conducted for this research, it can be said that during the COVID-19 pandemic, Taiwanese citizens' trust in the government increased. Only a small minority of the interviewees doubted that the government released all of their data or assumed that they released it later to influence people's response to avoid a panic. Although some interviewees did not trust the government to disclose all data, they stated that they trust the government to address the pandemic and that it may be necessary to exclude some data to avoid instigating panic.

The majority of the interviewees had full trust in their government; however, they stated that citizens are also responsible to fight the pandemic through mask usage, hand sanitisation, and general obedience to implemented measures. These interviewees believed that the government were honest with the offered COVID-19 data and that they did not hide anything. When asked the reason for their trust in the government, the majority said that the government informed them through daily TV briefings and that the data are accessible not only through TV but also through the Internet and even the mobile application ‘Line’. Taiwan's government have been open with information about COVID-19 and has even encouraged citizens to be in dialogue with the government through events such as the online town hall (Su & Han, 2020). Furthermore, the majority of the interviewees answered that the government has demonstrated leadership and organisational skills, agreeing that both the government and citizens must work together in the fight against the pandemic and that Taiwan will recover swiftly from the pandemics’ economic consequences. A minority of the interviewees did not expect Taiwan to recover quickly economically from the pandemic but added that the government will do everything to support this recovery.

The majority believed that the government treats its citizens fairly and equally, although a small minority of interviewees disagreed, since in their opinion, health workers do not receive fair treatment. They said that, generally, health workers do not receive adequate support, as they must work longer hours, often earn less (since their salaries were reduced by the hospital), and face discrimination based on their occupation, such as the loss of living spaces, exclusion from certain supermarkets, and rejection from delivery services that refuse to deliver food to hospitals. These interviewees stated that the government should have done more to protect the health workers from this kind of discrimination and should have increased support of health workers' mental well-being. Others mentioned that some health workers receive gifts and support from society and were not required to pay rent for three months as a gift from their landlord for their service. When the interviewees were asked whether they had sufficient PPE, all answered affirmatively, stating that they had more than needed; however, a small minority commented that, initially, Taiwan suffered briefly under mask shortages.

Furthermore, based on their experience in the COVID-19 pandemic, interviewees observed that the government has controlled the pandemic in Taiwan while other countries have fared worse; Taiwan has not experienced a lockdown, and citizens have maintained their everyday lives. Consequently, the government's organisational skills have increased their trust in the institution and decreased their fear (Yen, 2020). Additionally, the majority of the interviewees said that they trust the government because the government reacted quickly and continues to adjust measures to the situation, which increases their confidence in their government. Han

(2020) also supports this hypothesis of trust in Taiwan's national government. Therefore, it can be concluded that trust in the government is one reason for the low spread of the virus in Taiwan.

4.3.3) Taiwan's SARS Experience

In 2003, the SARS pandemic substantially affected Taiwan (Lin et al., 2020a; Lin et al., 2020b; Lin et al., 2020c). Similar to COVID-19, SARS began in Mainland China (in Guandong). In Taiwan, the majority of cases involved health workers who were infected in the hospitals (Lin et al., 2020b). The country faced two predominant problems during the SARS pandemic: the shortage of necessary PPE for health workers and the lack of knowledge about how the virus spreads (Lin et al., 2020b).

Consequently, the virus spread rapidly (Lin et al., 2020b). From 14 March to 30 July 2003, 668 people tested positive for SARS; 181 of these people died, which equals 27% of total infections (Chen et al., 2005), making it the highest SARS mortality rate globally (Ul Khaliq, 2020, as cited in Meichle & Torres Lajo, 2021). The high mortality rate led to general panic in the Taiwanese population (Yen, 2020).

Since the Taiwanese government and population learnt through the SARS pandemic the importance of hand washing and that the transmission of viral respiratory diseases can be reduced through mask wearing, the usage of health measures was implemented swiftly in the COVID-19 pandemic (Su & Han, 2020; Lin et al., 2020c; Chiu et al., 2020; Chung & Chou, 2020). Furthermore, this experience led the Taiwanese population to be highly alert and sensitive to the current pandemic (Chung & Chou, 2020)

The opinion about SARS in connection to the COVID-19 pandemic was revealed in the interviewees' answers: they believed that it has been common to wear a mask in Taiwan during COVID-19. They also stated that since they no longer want to experience something as devastating as the SARS pandemic, they wear masks and follow the implemented or recommended governmental measures.

However, the government also learnt from the SARS experience. During that pandemic, the government had already started to plan for a future health crisis by establishing the National Health Command Center and revising the Communicable Disease Control Act (Taiwan

Centre for Disease Control, 2020a; Yen, 2020). If another health crisis were to emerge, then the National Health Command Center would be utilised as a command point (Yen, 2020).

Furthermore, the National Health Command Center comprises an essential subunit: the Central Epidemic Command Centre. The Central Epidemic Command Centre consist of multidisciplinary experts (Yen, 2020). The revised Communicable Disease Control Act grants the government the power to react quickly in public health emergencies and dispatch resources as needed (Yen, 2020; Taiwan Centre for Disease Control, 2020a). For example, the Communicable Disease Control Act enables the implementation of “a disease control network by dividing the country into regions; [and] establishing a centralised platform to command and coordinate agencies' actions” (Lin et al., 2020b, p. 256). This regional division leads to better communication between the government and citizens and simplifies the communication between the subnational and national levels (Yen, 2020).

Additionally, the revised Communicable Disease Control Act enables the government to “share information and respond to inquiries, integrate personnel, facilities, and resources in preparation for outbreaks, issue voluntary and mandatory isolation orders and implement border restrictions” (Lin et al., 2020b, p. 256). Moreover, it provides the Central Epidemic Command Centre the legal authority to punish citizens who violate mandatory governmental measures (Yen, 2020). The revised Communicable Disease Control Act also enables the Centre for Disease Control, which is part of the MOHW, to decide what constitutes a public health emergency (Lin et al., 2020b, as cited in Meichle & Torres Lajo, 2021). Another institutional change that resulted from the SARS pandemic was the establishment of the Communicable Disease Control Medical Network, which is responsible for the management of medical resources (Lin et al., 2020b).

4.4) Nonpharmaceutical Interventions

This section focuses on the essential elements in the Taiwanese NPIs with regard to combatting COVID-19. According to Lin (2020b) and Chien et al. (2020) the key factors of Taiwan's success are: the optimisation of medical supplies, the implementation of border control and travel bans, the implementation of quarantine, the usage of big data for tracking and tracing infected individuals, the communication between the state and the population, and the employment of NPIs.

4.4.1) Mask Production, Distribution, and Usage

Face Mask Production

Medical supplies, especially face masks, have been essential in the pandemic. Mask usage during the pandemic has been rampant, although the government did not initially implement any mandatory mask measures but recommended mask wearing; however, the majority of public and private organisations expected people to wear a mask before entering (Hsieh et al., 2020a). Masks wearing has especially been expected in medical institutions (Hsieh et al., 2020a). On 1 April 2020, mask wearing became mandatory in public since the infection rate increased (Hsieh et al., 2020a).

Before the pandemic, Taiwan produced approximately 1.88 million masks per day for national usage and imported 40% of the additional necessary medical supplies, including masks, from Mainland China (Su et al., 2020; Kuo et al., 2020). At the beginning of the pandemic, a global mask shortage (Lin et al., 2020a; Yen, 2020) occurred because of the increased global demand. Countries, especially those in the Global North that depended on the global supply chain, were drastically affected (Zhou, 2020, as cited in Meichle & Torres Lajo, 2021). Consequently, many countries stopped exporting face masks (McMahon et al., 2020). Accordingly, China, which produces 50% of all masks globally (Wu et al., 2020a), banned the exportation of face masks (Deutsche Welle, 2020, as cited in Meichle & Torres Lajo, 2021). Furthermore, the COVID-19 outbreak in Wuhan occurred during the Chinese New Year, which added to the mask shortage because the majority of mask-producing factories were closed for the holiday (Wang et al., 2020a; Wu et al., 2020a); this led to the inability to immediately increase production (Meichle & Torres Lajo, 2021). This shortage led to modern piracy; for example, some countries intercepted mask deliveries at the airport, offering additional money to sellers (Okello, 2020; Gehrke, 2020). Consequently, the Taiwanese government established a fixed price to avoid bidding wars (Chiang et al., 2020).

Although mask production is not a skill-intensive procedure, acquiring the necessary raw materials and machines needed to produce them became challenging (Yen, 2020). Taiwan quickly implemented measures to ensure that its approximately 24 million citizens received masks (Meichle & Torres Lajo, 2021). Before the first case was diagnosed in Taiwan, the nation had already generated a supply "of 44 million surgical and 1.93 million N95 masks" (Chiang et al., 2020, p. 1). Anticipating increased national demand, the government implemented an export ban on medical masks within three days of the first reported COVID-19 case in Taiwan (24 January 2020) to avoid panic buying and mask hoarding, which occurred during the 2003 SARS pandemic, and to ensure a sufficient supply of masks for its citizens (Chiang et al., 2020; Rowen, 2020; Lin et al., 2020b; Chiang et al., 2020; Lee, 2020; Su et al., 2020; Yen, 2020).

The global mask shortage and Taiwan's challenge of providing masks for its citizens further compelled the government to increase local mask production (Meichle & Torres Lajo, 2021; Rowen, 2020). Accordingly, the Taiwanese government invoked Article 54 of the Communicable Disease Control Act to increase the national mask production (Chiang et al., 2020; Lee, 2020; Lin et al., 2020, 2020; Su et al., 2020; Yen, 2020). Article 54 states the following:

> "During the period the central epidemic command center is in existence, government organizations at various levels, in accordance with instructions of the commanding officer, may expropriate or requisite [s.i.c.] private land, products, buildings, devices, facilities, pharmaceuticals and medical devices for disease control practices, facilities for the treatment of contamination, transportation means, and other designated disease control resources announced by the central competent authority, and adequate compensations shall be made to appropriate parties.
>
> Operational procedures, methods of compensation and other matters to be complied with for the expropriation and the requisition mentioned in the preceding Paragraph shall be decided by the central competent authority". (Ministry of Justice, 2019)

"In February, the Industrial Development Bureau of the Ministry of Economic Affairs (MOE) and the Taiwan Textile Research Institute —an institution funded by the Taiwanese government R&D for the textile industry" (Yen, 2020, as cited in Meichle & Torres Lajo, 2021, p. 7) met with several manufacturers in mask-related fields, including manufacturers of raw materials, face mask machines, and face masks (Yen, 2020). Manufacturers and the government agreed on a plan to increase production (Yen, 2020), and the Taiwanese government managed this plan (Yen, 2020).

Taiwan invested US$6.66 million in 60 mask production lines (Lin et al., 2020), which were built within a month (Meichle & Torres Lajo, 2021). The Taiwan Mask Corporation, located in Paoshan Hsiang (Meichle & Torres Lajo, 2021), and 14 other private companies produced 72 million masks for the Taiwanese government, and the government provided the machinery (Teng, 2020). These masks were delivered at the beginning of March, and manufacturers needed only 25 days to produce them (Teng, 2020). By the middle of March, the additional production capacity led to the manufacture of 10 million masks per day, which rose to 16 million masks per day by the end of March (Chiang et al., 2020; Yen, 2020).

The Taiwanese government built another 32 mask production lines and invested, in total, US$9.6 million (including the initial $6.66 million) to build 92 new face mask production lines (Yen, 2020; Su, 2020, as cited in Wu et al., 2020a). Consequently, by the end of March 2020, Taiwanese plants were producing nearly 20 million masks per day (BBC Future, 2020), which enabled the government to distribute masks to health workers, schools, and airport control workers (Lin et al., 2020b). Additionally, to increase domestic mask distribution, Taiwan implemented a national, name-based mask distribution system (Lin et al., 2020a; Lin et al., 2020b; Rowen, 2020; Su & Han, 2020; Yen, 2020) to prevent panic buying (Chiang et al., 2020) and guarantee universal access to masks (Huang, 2020b).

Face Mask Distribution and Usage

On 6 February 2020, Mask Rationing Plan 1.0 was announced (Su & Han, 2020; Tai et al., 2021; Huang, 2020a; Chiang et al., 2020). While this plan was active, it allowed health workers to purchase up to two medical masks in one of the 6,505 NHI-contracted pharmacies (Su & Han, 2020) per day, while regular citizens were permitted to purchase three masks per week (Tai et al., 2021; Huang, 2020a; Chiang et al., 2020). Each mask could be purchased for approximately US$0.17 (Su & Han, 2020; Hsieh et al., 2020a). On 21 February, children were allowed to purchase four masks per week, which eventually rose to five masks per week, while adults were permitted to purchase three masks per week (Chiang et al., 2020). The only requirement for purchasing a mask was to present one's NHI card (Su & Han, 2020; Chiang et al., 2020; Tai et al., 2021; Huang, 2020a).

Furthermore, the MOHW created a real-time mask map website (Mask Finder; https://mask.pdis.nat.gov.tw). The website displays information regarding the stock of face masks in pharmacies to prevent long queueing for mask purchases (Lin et al., 2020c; Yen, 2020; Hsieh et al., 2020a; Tai et al., 2021). On 12 March 2020, Mask Rationing Plan 2.0 was implemented (Tai et al., 2021); it included new elements such as a mobile application that enabled people to preorder and reserve their weekly masks in convenience stores (Hsieh et al., 2020a; Tai et al., 2021). Additionally, the digital mask application was upgraded and offered additional "the pharmacy name, available quantity of adult-sized masks, available quantity of child-sized masks, opening hours, pharmacy phone number, pharmacy address, update time, and opening hours of nearby pharmacies" (Tai et al., 2021, p. 5)
Mask Rationing Plan 3.0 was implemented on 9 April 2020; at this time, domestic mask production was high in Taiwan, which enabled an increase in the allowable number of mask purchases for each person (Chiang et al., 2020; Tai et al., 2021, as cited in Meichle & Torres Lajo, 2021). Citizens were then allowed to purchase nine masks every 14 days (Chiang et al., 2020), while children could buy 10 masks every 14 days (Su & Han, 2020; Tai et al., 2021, as cited in Meichle & Torres Lajo, 2021). The government also created a website for people to purchase masks online and implemented mask machines in convenience stores (Su & Han, 2020; Tai et al., 2021, as cited in Meichle & Torres Lajo, 2021). Additionally, they continue to inform citizens through "websites, social media apps, and TV broadcasting" (Hsieh et al., 2020a, p. 3) regarding correct usage of masks as well as their functions (Hsieh et al., 2020a).

4.4.2) Border Controls and Travel Bans

Taiwan acted more quickly than the majority of countries in response to the outbreak in Wuhan (Hsieh et al., 2020a). The Taiwanese government had ordered in late December 2019 that flight passengers from Wuhan should undergo temperature checks through (Wang 2020, as cited in Hsieh et al., 2020a) "no-touch, video-recordable infrared thermometers" (Lin et al., 2020a, p. 1057). These devices were installed in the airport during the SARS pandemic (Lin et al., 2020a). On 31 December 2019, Taiwan implemented onboard health checks (Lin et al., 2020a; Cheng et al., 2020) and quarantine policies for passengers arriving from Wuhan (Su & Han, 2020).

Within a week, the Taiwanese government established a task force, forming an expert team that was specialised in “infectious diseases, public health, and laboratory sciences” (Lin et al., 2020a, p. 1056). The Centre for Disease Control staff checked passengers arriving from Wuhan for pneumonia symptoms, provided additional health information, and reported suspected COVID-19 cases to the Centre for Disease Control and the local health department (Lin et al., 2020a). This information allowed these facilities to monitor and transport people with respiratory symptoms or fever to a designated hospital (Lin et al., 2020a; Cheng et al., 2020).

Furthermore, individuals “with respiratory symptoms, fever, or presumptive pneumonia who had recently travelled Wuhan” (Lin et al., 2020a, p. 1506) were required to be reported immediately to the Centre for Disease Control (Lin et al., 2020a). The Taiwanese government also expanded its travel restrictions from only Wuhan, to include “Hubei, Guangdong, Zhejiang, and finally, China, including Hong Kong and Macau” (Wang, 2020, as cited in Cheng et al., 2020, p. 771; Rowen, 2020) in early January 2020 (Wang et al., 2020, as cited in Lin et al., 2020b).

On 15 January 2020, the government stated that there would be border controls and home quarantines for people that were affected by the SARS-CoV-2 virus (Lin et al., 2020a; Lin et al., 2020b). The Taiwanese government declared COVID-19 a Category V Communicable Disease on 15 January 2020 (Communicable Disease Control Act, Art. 3, as cited in Lin et al., 2020a), which led to the implementation of the Central Epidemic Command Centre on 20 January 2020 (Communicable Disease Control Act, Art. 17, as cited in Lin et al., 2020a). Beginning on 23 January 2020, the Central Epidemic Command Centre analysed the risk posed by Wuhan citizens and prevented any Wuhan resident from entering Taiwan (Lin et al., 2020b; Hsieh et al., 2020a).

Since then, passengers arriving in Taiwan have been required to complete a comprehensive health reporting card that includes all symptoms or illnesses, travel, and contact history (Lin et al., 2020a), and the Centre for Disease Control offered instructions on self-monitoring and home quarantine (Lin et al., 2020a). On 25 January 2020, the Taiwanese government suspended all tours to China (Lin, 2020b), and on 6 February 2020, it banned all Chinese citizens from entering Taiwan (Wang et al., as cited in Lin, 2020b).

On 14 February 2020, the Taiwanese government implemented the Entry Quarantine System: scannable QR codes led to online health declaration forms for passengers; completion was required before departure to or arrival in Taiwan (Wang et al., 2020a; Su & Han, 2020). Low-risk travellers received a mobile health report via SMS to obtain faster immigration clearance (Wang et al., 2020a). Based on the COVID-19 risk level, people were allowed to enter Taiwan but had to quarantine at home or monitor their health for two weeks. However, these measures were adjusted on 24 and 27 February 2020, when every passenger returning from South Korea and Italy was required to home quarantine because of the high numbers of infections in these countries (Cheng et al., 2020).

Soon, Italy, South Korea, and Iran as well as many other countries with high infection rates were added to Taiwan's prohibition list (Rowen, 2020). On 9 March 2020, the Taiwanese government banned all people from entering Taiwan (Aspinwall, 2020, as cited in Lin et al., 2020b) except for individuals who hold Taiwanese citizenship (Rowen, 2020).

Furthermore, Taiwanese citizens who were “medical personnel, civil servants and middle- and primary-school teachers, students, and staff” (Chen & Chiang, 2014, as cited in Lin et al., 2020b, p. 265) were prohibited or strongly discouraged from leaving Taiwan (Lin et al., 2020b). People in this category were not to travel because Taiwan wanted to maintain its health workers as resources and avoid transmission to vulnerable groups (Chen & Chiang, 2014, as cited in Lin et al., 2020b). On 21 March 2020, the Central Epidemic Command Centre implemented their strictest travel measure (Chiu et al., 2020): the travel warning was raised to Level 3 for all countries, and Taiwanese citizens were asked to avoid any trips to other countries if possible (CoronaNet, 2020). It can be said that Taiwan's rapid response with border controls and quarantine led to the inhibition of the spread of the virus within the country (Lin et al., 2020b).

4.4.3) Quarantine

The Taiwanese government assigned 16 hotels to be quarantine hotels (Lee et al., 2020, as cited in Chiu et al., 2020; Lin et al., 2020c) to protect citizens from infection and to reduce fear in the population (Chiu et al., 2020). Travellers from specific countries and individuals who had close contact with people whose cases were confirmed were required to quarantine for two weeks (Lin et al., 2020a); this included “self-isolation without going out or having visitors, recording temperature and symptoms twice daily, and if living with others, wearing a mask at all times and taking precautions with household members” (Lin et al., 2020a, p. 1508).

To support the surveillance of home-quarantined individuals, the Centre for Disease Control shared their contact information with local civil offices (Lin et al., 2020a). Twice daily, telephone calls or even home visits from health care workers were utilised to verify quarantine compliance (Lin et al., 2020c; Jian et al., 2020; Su & Han, 2020). Additionally, quarantined individuals self-reported via text messages or mobile application (Jian et al., 2020). If the phone signal of quarantined people disappeared, then the police were informed and visited these individuals to check their locations (Lin et al., 2020a; Lin et al., 2020c; Su & Han, 2020). If these individuals breached quarantine restrictions more than once, then they could receive a US$3,300–$33,000 fine, and losing their financial quarantine support (Taiwan Centers for Disease Control, 2020, as cited in Lin et al., 2020a; Lin et al., 2020c; Su & Han, 2020), or be quarantined in a state-designated facility (Lin et al., 2020a; Lin et al., 2020c; Su & Han, 2020).

Additionally, the Centre for Disease Control created a mobile application and upgraded it to the so-called Disease Prevention Butler, which consists of a chatbot with artificial intelligence that swiftly offers information to users (Lin et al., 2020a). This bot is also utilised in a two-way system to monitor quarantined individuals and reduce the burden on staff (Lin et al., 2020c). Moreover, local authorities collected waste from infected and quarantined individuals twice each week to reduce the risk of contamination (Lin et al., 2020c). If individuals have close contact with an infected person, then they are interviewed by phone or in person and tested for COVID-19 (Lin et al., 2020c). The Taiwanese government define *close contact* as “individuals who had unprotected physical contact with a [person with a] confirmed case within two meters for 15 minutes from two days before the onset of symptoms until the date of isolation” (Jian et al., 2020, p. 6).

As with those who arrive from high-risk countries, people who have had close contact with an infected person but test negative for COVID-19 must quarantine for two weeks (Su & Han, 2020; Lin et al., 2020c). Due to the ongoing outbreak in Taiwan, the Central Epidemic Command Centre offer free meals and daily financial compensation of US$30 to people in two-week home quarantine (Su & Han, 2020; Taiwan Centers for Disease Control, 2020, as cited in Lin et al., 2020c); this is only for people who do not receive paid sick leave (Taiwan Centers for Disease Control, 2020, as cited in Lin et al., 2020c).

A public 24-hour hotline is available for the quarantined who have any questions (Lin et al., 2020c).

Since 19 March 2020, the Taiwanese government have quarantined arriving tourists from all countries for two weeks in 134 specifically designated isolation hospitals (Taiwan Centers for Disease Control, 2020, as cited in Su & Han, 2020). Additionally, 52 hospitals and medical centres have been designated strictly for those affected by COVID-19 (Taiwan Centers for Disease Control, 2020, as cited in Su & Han, 2020). When Taiwanese citizens were evacuated from Wuhan, they underwent an in-flight quarantine process (Su & Han, 2020). Upon arrival, symptomatic people were directly quarantined in negative pressure isolation quarters. All symptom-free Taiwanese citizens who were evacuated from Wuhan were sent directly to allocated quarantine sites and were transported there in vehicles assigned specifically for this situation (Su & Han, 2020). These people remained in quarantine for two weeks, and their luggage was disinfected (Su & Han, 2020).

Students studying in Taiwan who visit their families in Mainland China self-quarantine in separate dorms (Lin et al., 2020a). After three negative SARS-CoV-2 tests, individuals are allowed to leave quarantine (Taiwan Centers for Disease Control, 2020, as cited in Su & Han, 2020). Based on Chen et al. (2020), effective border quarantines are a major factor in successfully containing the spread of SARS-CoV-2. Consequently, the transmission of the virus through imported cases is reduced, and medical institutions are prevented from becoming overwhelmed.

4.4.4) Tracking and Big Data

On 25 January, Taiwan's NHI administration adapted their data system to the database of National Customs to enable medical staff to check patients' travel history (Hsieh, 2020a; Lin et al., 2020a; Lin et al., 2020c; Wang et al., 2020a). Since all responsible institutions are required to upload the data within 24 hours, the information database is almost real-time (Lin et al., 2020a; Wang et al., 2020a). Due to NHI's wide coverage (Wang & Brook, 2020, as cited in Chiu et al., 2020), health workers know whether symptomatic patients have been in a high-risk country in the past 30 days (Hsieh, 2020a; Chiu et al., 2020).

Furthermore, the NHI card is utilised to screen the travel history of individuals entering the hospital to reduce the spread through those with potential COVID-19 cases (Chiu et al., 2020; Lin et al., 2020b). This co-operation between National Customs and the NHI allows the government to track potential cases based on travel history (Wang et al., 2020a). To simplify this process, the Taiwanese government utilise big data technologies to collect data about travel and contact history, [patients'] health records, [and] real-time movement (Lin et al., 2020b, p. 266) data of potentially infected individuals to detect potential cases and quarantine, track, or locate those people (Lin et al., 2020b). For example, via surveillance camera recordings and mobile phone tracking, the Taiwanese government published daily routes of infected individuals so the public was aware of cases to which they may have been exposed (Lin et al., 2020a; Chen et al., 2020, as cited in Lin et al., 2020b; Jian et al., 2020).

When the number of individuals quarantined at home reached tens of thousands, the Taiwanese government implemented a GPS tracking system to check the location and functionality of these individuals' mobile phones and receiving daily health reports about the quarantined individuals (Lin et al., 2020a; Cheng 2020, as cited in Lin et al., 2020b; Wang et al., 2020a; Taiwan Centers for Disease Control, 2020; Kluth, 2020, as cited in Su & Han, 2020). They also send 'automatic two-way text messages' to obtain responses from quarantined individuals (Jian et al., 2020). Furthermore, “cameras on personal or government-dispatched smartphones were used for monitoring and case identification” (Lin et al., 2020a, p. 1508). On 16 February, the Centre for Disease Control modified their definition of COVID-19 suspects to include all individuals, regardless of their travel history (Cheng et al., 2020). Two days later, the Taiwanese government provided access to patients' travel histories for health workers in clinics, hospitals, and pharmacies (Wang et al., 2020a).

The toll-free number 1922 was established to allow citizens to report potential COVID-19 symptoms in themselves or others (Wang et al., 2020a). Consequently, in April 2020, more than one-half of all daily health records were obtained through self-reporting (Jian et al., 2020). Once the toll-free number reached its capacity, each major city created hotlines (Wang et al., 2020a). Additionally, Taiwan implemented a "retrospective COVID-19 screening scheme" (Lin et al., 2020a, p. 1510) for individuals with respiratory symptoms who tested negative for COVID-19 two weeks prior (Lin et al., 2020a; Wang et al., 2020a). Consequently, the NHI database found 113 potential COVID-19 cases (Lin et al., 2020a; Wang et al., 2020a). It has been demonstrated that a database connecting institutions to mobile data monitoring can reduce the number of infections by controlling travel and contact history as well as compliance with quarantine measures (Lin et al., 2020b).

4.4.5) Communication

In health emergencies such as COVID-19, risk communication is essential to inform the population and ensure compliance with implemented measures by increasing citizens' trust, which is especially important in controlling such emergencies (Lin et al., 2020b). The Central Epidemic Command Centre implemented daily press conferences to inform citizens about COVID-19 prevention measures and health guidelines (Su & Han, 2020; Lin et al., 2020b; Lin et al., 2020c; Rowen, 2020). They also provide the

> reporting criteria of all pneumonia cases, testing and quarantine procedures, preparation of pharmaceutical and medical supplies, capacity ensuring of isolation wards, and public health education (mask wearing, temperature checking, hand washing, avoiding eyes, nose, and mouth touching, environmental disinfection, etc.). (Su & Han, 2020, p. 3)

Additionally, they explain the correct usage of hand sanitiser and gloves (Hsieh et al., 2020a). The Central Epidemic Command Centre co-operated with civic technology companies to establish a daily two-way communication platform between the Central Epidemic Command Centre and the population (Pu, 2020, as cited in Lin et al., 2020b). After every press conference, the Central Epidemic Command Centre offer an open question-and-answer session in which questions from the public and the media are addressed (Lin, 2020, as cited in Lin et al., 2020b). After the first COVID-19 case was identified in Taiwan on 22 January 2020, the Taiwanese Health and Welfare Minister, Chen Shih-Chung (Chiu et al., 2020), who is a well-known epidemiologist in Taiwan, aired a 90-minute press conference on television and online (Chiu et al., 2020; Wang et al., 2020a) in which he informed the Taiwanese population about the current situation based on case-by-case updates. Shih-Chung announced that citizens must wear a mask and stressed the importance of hygiene measures, such as hand washing, as well as the possible risks of mask hoarding (Wang et al., 2020a). The government also offer educational information about the COVID-19 pandemic on social media (Chiu et al., 2020; Pu, 2020, as cited in Lin et al., 2020b).

According to the information provided by the Central Epidemic Command Centre and Shih-Chung, the Taiwanese government attempt to be transparent and offer knowledge to ease anxiety (Chiu et al., 2020). However, the Taiwanese government do not merely provide information but also maintain regular contact with citizens (Lin et al., 2020b); hence, they offer avenues to address citizens' questions, fears, and critiques (Lin et al., 2020b). Through this dialogue, the Taiwanese government attempt to generate trust and create a general awareness of the situation (Lin et al., 2020b).

Additionally, to keep the population informed and in regular contact, the Taiwanese government oppose misinformation and fake news (Wang et al., 2020a; Lin et al., 2020b). As part of this fight, Taiwanese authorities impose fines or arrest individuals who broadcast fake news related to COVID-19 (Hioe & Wooster, 2020, as cited in Lin et al., 2020b). This has resulted in a high and stable approval rate of more than 70% for Taiwan's president (Rowen, 2020) as well as over 80% for Shih-Chung and his management of the pandemic (Wang et al., 2020a).

4.4.6) Other Nonpharmaceutical Interventions

Since Taiwan learnt from the 2003 SARS outbreak, it created strategies to control the spread of a virus that have been implemented in the COVID-19 pandemic (Lin et al., 2020a). Hospitals have also installed screening booths to check the temperature of every person who enters (Lin et al., 2020a). Furthermore, they provide hand sanitiser and isolate people with potential COVID-19 symptoms (Lin et al., 2020a). Since 30 January 2020, the Taiwanese government have utilised the state-owned Taiwan Tobacco and Liquor Corporation's distillery factories to produce medical-grade alcohol to ensure a sufficient supply of hand sanitiser for both institutions and citizens (Hsieh et al., 2020a). Due to the high production of medical alcohol, the majority of locations have been able to provide sanitiser at each building entrance and in important public places such as “ticket-sales windows, railway entrances, and airport customs with its fingerprint scanners” (Hsieh, 2020a, p. 2).

Furthermore, the government have allocated the distribution of three-litre containers of alcohol to public locations that are critical in lowering the spread of the virus. These locations include governmental facilities, schools, the MRT, airports, and medical facilities (Hsieh et al., 2020). Secondary priority locations include “restaurants, factories, and supermarkets” (Hsieh et al., 2020a, p. 3). Finally, the remaining alcohol has been allocated to convenience stores and pharmacies, where it is available for anybody to purchase (Hsieh et al., 2020a). Consequently, utilising hand sanitiser when entering “schools, hospitals, businesses, apartment complexes, and cultural sites/events” (Lin et al., 2020c, p. 4) as well as temperature checks became a standard procedure in late January (Lin et al., 2020c).
Hsieh et al. (2020a) state that Taiwan’s mass masking and universal hygiene were remarkably unique. Universal hygiene entails not only hand hygiene but also everything people may have touched; therefore, it involves cleaning surfaces and eliminating certain fomites (Hsieh et al., 2020a). Accordingly, plexiglass walls in locations such as schools, banks, public institutions, and restaurants; restrictions on social gatherings; and social distancing (one metre outside and one-and-a-half metres inside) measures have been implemented (Chiu et al., 2020; Lin et al., 2020c).

Furthermore, the number of people allowed in restaurants and theatres has been reduced, and people must provide their contact information in case contact tracing becomes necessary (Lin et al., 2020c). The Central Epidemic Command Centre emphasises that if people cannot maintain the required distance, then they must wear masks (Lin et al., 2020c). Taiwan has also increased the amount of PPE for health workers and has created a national inventory of available negative pressure isolation rooms and intensive care rooms (Cheng et al., 2020).
As soon as China published the genome sequence of the SARS-CoV-2 virus, the Taiwanese Centre for Disease Control established appropriate RT-PCR tests (Corman et al., 2020; Zhang, 2020, as cited in Cheng et al., 2020). “Laboratory protocol and reagents, including primers, probes, and positive control” (Cheng et al., 2020, p. 772) were rapidly allocated to specific laboratories (Cheng et al., 2020). To increase laboratories' testing capacity, the Centre for Disease Control initiated a national programme, resulting in 27 laboratories that performed 2,250 molecular SARS-CoV-2 diagnostics per day by 21 February 2020 (Cheng et al., 2020). Eventually, 37 additional laboratories became qualified to perform COVID-19 tests, thus reaching a testing capacity of 3,900 cases per day (Su & Han, 2020).
Cheng et al. (2020) believe that one of the critical factors in successfully preventing an outbreak is the laboratory capacity and swift diagnosis of cases (Yang et al., 2017, as cited in Cheng et al., 2020). Chien et al. (2020) also state that universal public mask wearing and

social distancing in outdoor areas led to the ability to lower the infection rate in Taiwan and thus avoid a lockdown or closure of public places and transportation.

Chapter Five: Discussion

In late 2019, an outbreak of an unknown respiratory disease occurred in Wuhan. The disease was later determined to be COVID-19, a sickness produced by the SARS-CoV-2 virus. The virus rapidly spread worldwide from Wuhan and infected millions of people, leading to a global pandemic. Most countries were unprepared for such a pandemic and were seriously affected; they experienced difficulties controlling the spread of the virus. Although many countries implemented measures to fight the virus, they were unsuccessful much of the time. As colder seasons are now approaching in many countries globally, there is a significant increase in the number of infections. Most governments do not have the means or knowledge to reduce or stop the virus from spreading; their risk mitigation measures often do not curtail the spread. Epidemics and pandemics have been occurring more frequently due to climate change, humanity's increased interference with nature, and the destruction of natural habitats (Commission on Global Health Risk, 2016).

Examining the COVID-19 pandemic, Taiwan appears to be coping well with few new infections and a low overall infection rate. To lower the global infection rate, one must analyse Taiwan's strategy in the pandemic and determine which factors have affected the spread of SARS-CoV-2. The purpose of this study is to understand why Taiwan has outperformed other countries during the COVID-19 pandemic. Ultimately, this analysis is essential to improve understanding of the spread of airborne diseases and enhance future preparedness. Even though this analysis does not lead to a one-size-fits-all solution, the gathered knowledge can be utilised in the fight against future pandemics.

In this thesis, data were gathered and analysed to understand which factors had the strongest effect on the low COVID-19 case numbers in Taiwan and what can be learned from the Taiwanese approach. The results of this analysis show that the main factor in keeping COVID-19 cases under control was the early implementation and continuous adaptation of risk mitigation policies. Especially effective have been the early implementation of border controls, border restrictions, and travel bans; sufficient supply of PPE; strict implementation and control of quarantine measures; usage of big data to track potential cases and quarantined individuals; open access to sources of information about the COVID-19 pandemic and related topics; organised distribution and usage of PPE, like face masks and hand sanitiser; and use of NPIs like temperature screening booths and hand sanitiser dispensers in public places, universal hygiene, social distancing, plexiglass walls, and increased laboratory capacity to conduct tests.

Since most COVID-19 cases are imported, especially the implementation of border controls and travel bans kept the spread of the virus low since individuals from high-risk countries were not allowed to enter and individuals from countries that were allowed to enter had to undergo health checks, which reduced the risk of importing the SARS-CoV-2 virus. When a COVID-19 case was detected, the infected individual was instructed to quarantine immediately. The quarantine measures were effective since they were controlled with several measures like automatic two-way text messages and locating the mobile phones of quarantined individuals through GPS data. Furthermore, high fines, the loss of financial benefits, and the chance of being relocated by government officials to state-designated quarantine locations made sure that the breach of quarantine was taken seriously. The tracking of symptomatic individuals as well as those put at risk of infection through either close contact with an infected individual or being at the same location and time as an infected individual, decreased the chance to miss potential COVID_19 cases.

Furthermore, the daily briefing of het Taiwanese government as well as the opportunity after each press conference of the CDC for press as well as citizens to ask questions, was a key measure for inhibiting infection numbers, since it led to high trust in the government, which in turn led to high compliance with the measures. Moreover, Taiwan significantly increased mask production, which led to a high stock of masks, and implemented a mask-distribution system, which resulted in a sufficient availability of face masks and equal distribution in the population, which prevented panic buying and mask hoarding. Increasing the production of medical alcohol led to a sufficient supply of hand sanitiser, which was an important NPI for individuals as well as the government that implemented universal hygiene measures. The augmented laboratory testing capacity was another important factor that led to the ability to test enough individuals to detect the majority, if not all, infected cases. Previous research supports the argument that these NPIs reduce the spread of the virus. In particular, border controls, quarantine and quarantine management, risk communication, a reduction of crowding, contact tracing, the incorporation of travel data into contact tracing, mask usage, individual hygiene measures, social distancing, and the reduction of non-essential travel proved to be effective risk mitigation measures.

Sociocultural factors like trust also played a key role in reducing the spread of the virus since the citizens' high level of trust in the Taiwanese government led them to adhere to the implemented measures. The main reasons for the high trust of Taiwanese citizens in their government were the information the government offered on a daily basis as well as the frequent information exchange with the population. Providing COVID-19 related information made the citizens feel well informed and taken care of. This reduced fear among the population. Furthermore, citizens' perception of the government as organised and demonstrating leadership skills added to their high level of trust in the government. Taiwanese citizens generally believe that the government and citizens must work together in the fight against the pandemic. Additionally, most of the interviewees believe that the government have treated its citizens fairly and equally during the pandemic. All the Taiwanese citizens that were interviewed argued that they trust their government because it have controlled the pandemic in Taiwan very well and it acted swiftly early on and kept adjusting its policies to the situation while other countries have fared worse; Taiwan has not experienced a lockdown, and citizens have maintained their everyday lives. Moreover, the interviewees showed a high level of trust in the competence and willingness of the Taiwanese government to overcome the economic burden of the pandemic.

Sociocultural factors reinforced the policy measures. Another sociocultural factor, the mask usage of Taiwanese citizens, played a key role in keeping the spread under control. Mask wearing has globally been found to be a significant factor in controlling the virus. The historical roots of mask wearing in East Asia, the mask education in Taiwan, the already familiar usage of masks before the pandemic, and the positive attitudes towards mask wearing in Taiwan led to a high level of compliance for mask wearing in contrast to some western countries where people rejected the idea of wearing a face mask and rebelled against it. Based on the conducted interviews, as in other East Asian countries, masks were already worn before the COVID-19 pandemic on a daily basis to protect oneself against air pollution or allergic reactions or to prevent the spread of illness if an individual felt sick. Some interviewees even mentioned that they were educated about the benefits and proper usage of masks in kindergarten and primary school, which led them to view mask wearing as a natural behaviour. Furthermore, masks offer a certain kind of privacy in public.

Additionally, Taiwan's experience with SARS in 2003 left its mark on the population. It led to higher mask usage after the pandemic, citizens being more cautious about health crises, and legal and institutional changes that made it possible to be better prepared for the next pandemic, which turned out to be the COVID-19 pandemic. The legal and institutional changes allowed the Taiwanese government to react faster, implement the necessary policies, and fine individuals who violated them. Moreover, the changes allowed the government to act more organised and improved its communication with its citizens on national and subnational levels. Additionally, the changes allowed the government to dispatch resources as needed. It must be acknowledged that the Taiwanese climate is less favourable for the virus, which has resulted in a decreased infection risk compared to other countries. Even though the Taiwanese climate is less favourable for the virus due to its high humidity, mild temperatures, and lack of substantial seasonal differences, it does not seem to be one of the key factors. The NPIs that were implemented from the start of the pandemic on, were much more important for curtailing the risk of the spread of the virus. Although north Taiwan has a small climatic disadvantage if compared to south Taiwan, which has lesser infections, also the outbreak in the north was quickly under control due to the implemented NPIs. Furthermore, the NPIs as well as the high level of mask-wearing curtailed the risk factors PM2.5 and PM10, the levels of which are above the recommended on in Taiwan. Moreover, NO2 levels are quite low in Taiwan. Due to this the double-hit hypothesis does not hold for Taiwan, which is beneficial for the Taiwanese population. Masks are especially important in this scenario, since the pollution particles that transport and keep the virus in the air longer, will not be inhaled. The frequent mask wearing due to high air pollution, already before the pandemic started, also reduced the health issues that can occur because of the exposure to this pollution.

Sociodemographic factors have exerted a weak influence on the spread of the virus in Taiwan. Although intergenerational living and high population density were detrimental in the fight against the spread of the virus, the level of crowding, means of transportation and access to medical care had a positive effect in keeping the infection rate low. Socioeconomic class and age did not seem to affect the spread of the virus. Intergenerational living is a common practice in Taiwan, it could have led to a dramatic change in the outbreak of the pandemic in Taiwan like it did in Italy. However, by keeping the numbers low already from the start through a swift implementation of strict policies, Taiwan has been able to control the spread in intergenerational households from the younger generations and adults to the elderly. Population density could have posed a threat, but as the analysis of crowding showed, the population of the densely populated island did not cluster most of the times, which lowered the risk of infection. The medium number of household crowding with on average three people living together corroborates this. Also the measures aimed at keeping adequate distance and at reducing gathering at touristic spots as well as national and international tourism, played a role. Crowding was also reduced because citizens were afraid of getting infected due to difficulties of keeping adequate distance. Furthermore, crowding in public transport has not been a risk factor since only a small part of the population uses public transport while most of the population uses private transport. The use of public transportation decreased in the pandemic, which reduced the risk further together with the high mask usage in public traffic. Universal and affordable medical care offered by the Taiwanese government has led to the good health of its citizens in general, which makes them less vulnerable to infectious diseases than people with pre-existing conditions. For example, undernourishment, which is the case of Taiwan is low and comparable to the levels of western countries. Since the NHI covers more than 99% of the Taiwanese population, it could easily be deployed for certain policies, such as combining travel data with health records of individuals. This allowed the medical sector to react faster, if they encountered an individual with respiratory problem who had arrived recently from a high risk country. Moreover, the Taiwanese health system is prepared for health emergencies since it has 1,100 beds in negative pressure isolation rooms and 21,000 beds in isolation rooms which would have been essential if the infection numbers would have increased drastically. Furthermore, the special training for health emergencies and the sufficient supply of PPE have led to a well-prepared medical sector.

Even though some demographic factors seemed to pose risks in the pandemic, the overall effectiveness of the implemented NPIs reduced the impact of those potentially negative factors. The lesson that can be learned from Taiwan’s response to the COVID-19 pandemic, is that rapid implementation of policies such as border controls, health checks, quarantines and sufficient medical supplies, is essential. However, policies alone are not enough. If the government do not offer information and does not answer questions in order to gain citizens' trust, people will be less likely to follow the implemented measures, with the chance that the spread of the virus will increase. The findings of this study underscore the importance of both the implemented NPIs and sociocultural factors for controlling the pandemic, as was expected.

Chapter Six: Conclusion

In chapter seven the concluding points of the discussion will be summarized, the research questions will be answered, limitations of the research will be discussed and recommendations for future research will be stated.

This research aimed to address the following questions:

1.) What is the impact of meteorological factors on the spread of SARS-CoV-2 in Taiwan?
2.) What is the impact of demographic factors on the spread of SARS-CoV-2 in Taiwan?
3.) What is the impact of sociocultural factors on the spread of SARS-CoV-2 in Taiwan?
4.) What is the impact of the implemented nonpharmaceutical interventions on the spread of SARS-CoV-2 in Taiwan?
5.) What can be learnt by Taiwan's COVID-19 response for future preparedness?

By answering these research questions, the thesis attempted to create a deeper understanding of the situation in Taiwan during the COVID-19 pandemic and what led to the island's success in containing the spread of the virus. Literature (mainly research papers) and interviews were utilised to analyse these questions. The literature offered existing knowledge regarding certain factors that have affected the spread of the virus, while the interviewees enabled the understanding of specific sociocultural patterns. Based on the analysis, it can be concluded that sociocultural factors and implemented NPIs have led to Taiwan's success in the fight against the virus, since they have demonstrated a strong negative effect on the infection numbers of SARS-CoV-2. Nevertheless, it must be acknowledged that the Taiwanese climate has also had a negative effect on the spread of SARS-CoV-2; this has decreased the infection risk compared to other countries. Generally, demographic factors have not seriously affected the spread of the virus; some of these demographic factors did not affect the spread at all, while some others appeared to favour the spread of the virus, in the end cancelling out the overall impact of the demographic factors.

The results indicate that sociocultural factors, and the implemented NPIs have led to the success of Taiwan’s fight against the virus.

What can be learnt from Taiwan’s COVID-19 response for future preparedness is the need for rapid implementation of measures and sufficient medical supplies; however, these alone are not enough. The government must offer enough information to gain citizens' trust; this encourages citizens to follow the implemented measures.

COVID-19 infections do not indicate an obvious pattern, and science continues to question why COVID-19 is worse in one country than another; thus, it was necessary to examine this problem with an interdisciplinary analysis to create a holistic approach to explain the problem. Since this paper covers several fields, working with the existing research is the only avenue from which to gather current data. To the author's knowledge, little or no literature exists regarding Taiwanese sociocultural factors in the COVID-19 pandemic; consequently, in-depth interviews were necessary. Before analysing the various factors, it was assumed that the demographic factors would significantly affect the increase in the number of infections, while meteorological factors would have only a weak positive or negative effect on the spread. The meteorological factors in Taiwan have been unexpectedly beneficial in the fight against SARS-CoV-2, and the effects of demographic factors on the virus spread have been slight. This research illustrates which factors have had stronger or weaker influence on the low number of COVID-19 cases in Taiwan; It also, albeit perhaps tentatively, answered the question of how much each factor has affected the infection rate.

Consequently, governments should consider the factors mentioned in the analysis to understand which factors have affected the virus spread in their country so that they can adapt the implemented measures and learn how to react in future health crises. Future research should focus further on an analysis with several factors to acquire a deeper understanding of how much each factor influences the spread of disease, under which conditions the influence is exerted, and whether additional factors should be considered.

To the author's knowledge, this is the first interdisciplinary paper to combine several factors in an analysis to create a holistic approach and to explain the spread of a disease in a pandemic from more than one field. Since no similar approach to date exists in science, this research closes a gap in which the majority of scholars work with only a few factors in one or perhaps two fields; this results in limited understanding of the problem and findings. This challenges all theories that argue that factors from only one or two fields lead to the difference in infection rates. By creating this holistic approach, scientists will better understand the COVID-19 pandemic and know what to consider when implementing measures. Based on the case study of Taiwan, governments can adapt strategies to fight the current pandemic and create prophylactic measures for future preparedness since increased human interactions with nature and global warming have increased the appearance of epidemics and pandemics. Scientists do not know when the next pandemic will hit, but they know that it may be sooner than expected and that all must be prepared.

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