# The Role of Disparity in Travel Behavior in the Disproportionate Impact of Covid-19 on Ethnic Minorities in the Netherlands

**Vincenzo Giancaspro**

# The Role of Disparity in Travel Behavior in the Disproportionate Impact of Covid-19 on Ethnic Minorities in the Netherlands

By

**Vincenzo Giancaspro**

MASTER OF SCIENCE THESIS

For the degree of Master of Science in Complex Systems Engineering and Management at Delft University of Technology

To be defended publicly on Monday August 23, 2020 at 13:00

Student number: 5086469

Supervisor: Prof. dr. B. van Wee TU Delft

Thesis committee: Dr.ir. M. Kroesen TU Delft

Thesis committee: Dr. W.W. Veeneman TU Delft

# Acknowledgments

This thesis represents the culmination of a journey undertaken two years ago and the last page of a crucial chapter in my life. Studying at TU Delft has not only allowed me to learn from some of the brightest minds out there, to have gained a unique and in-depth understanding of the socio-technical dynamics of our society, but it has also allowed me to enrich my cultural baggage. These two years gifted me with cherished memories and precious friendships.

To begin, I would like to express my deep and sincere gratitude to Dr. ir. Maarten  for his invaluable guidance throughout this study. His deep understanding of travel behavior, expertise in methodology to conduct research in this field, and constant support has helped me overcome challenges and setbacks throughout this thesis and gain unparalleled insights that fueled my interest in this field.

I also owe a deep sense of gratitude to Dr. W.W. Veeneman for his keen interest in my research, for allowing me to bridge my research to a policy perspective, and for his intellectual guidance that helped me create insightful recommendations out of unforeseen results. His expertise enriched my study and my understanding of the transport policy field.

I also would like to thank Prof. Dr. B. van Wee for accepting the role of chair of my graduation committee. His extensive and meticulous feedbacks during my kickoff and green-light allowed me to improve every aspect of my research and to really think like a researcher. His profound expertise has taught me a lot in such a little time.

Last but not least, my deepest sense of gratitude goes toward every single person that supported me and allowed me to become the person that I am today. To my family, my support network, without you, these words would have gone unspoken. I have experienced your unquestioned guidance day after day, and my accomplishments are a reflection of yours. To my friends, you have been the driving force that pushed me to improve myself and achieve every goal that I have set for myself so far. My entire gratitude for you all cannot be articulated and summarized in a simple sentence. I will continue to express it in person.

E questo e’ tutto. Grazie.

Vincenzo Giancaspro

# Executive Summary


## Problem Statement and Research Gap

Covid-19 has disrupted social norms and economic stability across the world. As the virus disseminated across nations, researchers rushed to delineate the causes and the consequences of the spread of the virus. Early findings highlighted a concerning disproportionate impact of Covid-19 among ethnic minorities, which have been disproportionally victimized by the novel respiratory virus, with studies reporting up to 3.6 times the likelihood of infection for ethnic minorities compared to their white counterpart (APM Research Lab, 2021; USA Facts, 2020; Gross et al., 2020). Early studies indicated healthcare and socio-economic inequities as fosters of the pandemic and its discriminatory behavior. However, weeks into the pandemic, researchers also identified transportation as another significant contributor to outbreaks and as a contributor to the disproportionate impact of Covid-19 among ethnic minorities (McLaren, 2020). Although much research has been conducted in assessing the effect of Covid-19 and imposed social distancing on people's travel behavior and vice versa (with contrasting findings), considerably less attempted to discover the role that different travel behavior - with a special focus on public transport - played in the disproportionate impact of Covid-19 among ethnic minorities (McLaren, 2020). The absence of studies, even more Netherlands-based that investigate the role of disparity in travel behavior in the disproportionate impact of Covid-19 suffered by ethnic minorities, and the moral obligation at contributing to the scientific community at unveiling the fundamental sources of ethnic disparity to attempt to outline a remedy to it, have encouraged the development of this study.

## Why is it Important to Include Ethnicity in this Study?

This study presses on the importance of discussing ethnicity in the relationship between travel behavior and Covid-19 implications because ethnicity and travel behavior are deeply intertwined, and the Covid-19 pandemic made it clear. The pandemic has shown that people's ability to change means of transport in a time of crisis fundamentally depends on their socio-economic ability to do so more than on their personal preferences or mere will. Ethnicity and its influence must be considered to understand the real nature behind the role of travel behavior in the evolvement of the Covid-19 pandemic. Not doing so will veil the truth in the relationship between transport and Covid-19 and will continue to deepen this disparity because of the inability to outline informed and diligent policy interventions.

## Research Questions, Methodology, and Data Specifications

In order to fill the research gap, this study seeks to provide an answer to the following main research question:

*To what extend disparity in travel behavior is influencing the disproportionate incidence of Covid-19 infections and deaths among ethnic minorities? And how can policy-makers and public transport providers best adapt public transport to future discriminatory health crises?*.

The answer to the main research questions and the related sub-questions (*Chapter 1.5*), will be formulated through the combination of a comprehensive literature review, a statistical analysis through the Structural Equation Modeling (SEM) technique, and with the execution of a policy analysis study. Firstly, the literature review will be used to develop an in-depth understanding of the Covid-19 implications on the multidimensional ethnic disparity experienced by minorities in the Netherlands and on the actual nature of this disparity in the Netherlands. Results from the literature review will be used as inputs for the conceptual model that will later function as the

theoretical guideline for the rest of the study. The conceptual model will represent the theory and the logic backbone of the SEM analysis. Structural Equation Modeling is a statistical tool used in a wide range of fields, with a concentrated number of applications in the travel behavior field. It allows to analyze a researcher's theoretical model and capture the causal influences of the indicated exogenous variables on the endogenous ones and the casual influences among exogenous variables (Golob, 2011).

The dataset used for this study is obtained from Waarstaatjegemeente (VNG), a publicly available platform that bundles, processes, and presents data from and about all Dutch municipalities for everyone (Waarstaatjegemeente, 2019). These 'dashboards' provides access to an extensive list of variables ranging from Covid-19 records, demographic, work & income to mobility for all the 353 Dutch municipalities in all important policy areas. It allows comparing variables between different municipalities, exposing the underlying municipality-specific conditions that might be at the origin of the problem.

The literature review that precedes the statistical analysis allows identifying the key variables that should be included in this study (if datasets are available). The analyzed variables that are included in this study are organized into six categories. The first one is named 'ethnic background' and refers to the ethnic composition of Dutch municipalities, thus having each ethnic group as a variable. It is followed by the 'socio-economic, demographic, and health' categories used to identify the underlying conditions of any socio-economic group. Then the 'travel behavior' category represents the mobility norms in the Netherlands, and it is composed of all the major mobility means. Lastly, the 'Covid-19 records' category refers to the measurable conditions on the impact of Covid-19 in the Netherlands. Each of these categories can not be simply measured by a single indicator; instead, it is composed of a variety of indicators obtained from extensive research and illustrated in *Table 6*.

Two models have been developed for this study, namely models 1 and 2. Model 1analyzed the situation by considering the mere demographic split between 'Dutch natives' and 'people with an immigrant background'. Since both ethnic groups are complementary and including both in a unique model would have resulted in multicollinearity, model 1has been split into two variations; the first took into consideration only 'Dutch natives', while the second only 'people with an immigrant background'. Model 2 instead analyzed the relationships described in the conceptual model (*Figure 5*) by considering a disaggregated view of the 'people with an immigrant background variable', diving among the biggest ethnic minority groups in the Netherlands.

## Structural Equation Modeling Results

Results from both models confirmed the notion that, in the Netherlands, ethnic minorities are more likely to suffer from Covid-19 infections and related hospital admissions but are not more at risk of death compared to their Dutch counterparts. At the same time, unlike the initial hypothesis, both models showed that public transport does not represent a key driver behind the development of Covid-19 infections, death, and hospital admissions; instead, other socio-economic variables and, most notably, spatial variables could be considered significant drivers of the Covid-19 pandemic. Moreover, both models diminished the intermediating role of public transport in the relationship between ethnic background and Covid-19 records by demonstrating that the registered positive relationship between ethnic minority groups and Covid-19 variables can be sourced to their direct relationships and thus to something that might not have been included in the study. Therefore, travel behavior and the other intermediating variables such as socio-economic variables do not

appear to contribute to the disproportionate number of Covid-19 implications among ethnic minorities. What the second model offers that the first does not is a deeper insight into how Covid-19 disproportionally impacts ethnic minorities. This model demonstrates that the registered disparity in healthcare outcomes varies between ethnic minority groups, showing the presence of disparity even within the ethnic minority segment of the population.

## Policy Implications

In conclusion, this study reveals that travel behavior has an insignificant role in the relationship between ethnicity and Covid-19 and thus might not be considered a significant contributor to the discriminatory behavior of the pandemic. However, results also show that it also does not have a role in the development of Covid-19 implications whatsoever. These policy-relevant findings go to support the scientific faction that seeks to debunk the notion that public transport is the main contributor to the spread of a virus. These results triggered a detailed study of current transport policy measures implemented by the Dutch government throughout the pandemic, intended to evaluate their effectiveness and implications on the service and its riders. Most of the transport-related restrictive measures were shown to be ineffective in reducing the number of infections, and other studies have shown that public transport did not have a key role in the spread of Covid-19, supporting the notion elucidated by this study's findings.

In the wake of this study's findings and policy analysis, this study proposes three alternative transport policy intervention schemes to policymakers and public transport providers, including a brief description of their potential epidemiological, economic, social, and mobility implications. All the following policy interventions are founded on the shared idea that restricting service frequency or enforcing service closure are not effective measurers, and therefore they will not be part of any policy intervention scheme. All three policy intervention schemes are designed to advise Dutch authorities and public transport providers on how to manage transport systems to enhance economic resilience and passenger's safety during a health crisis.

## Recommendations

Recommendations have been designed for both policymakers and future research. The first set of recommendations advises policymakers and public transport providers to use the suggested policy interventions scheme as the foundation for their intervention during a health crisis. Their approach is dictated by the epidemiological status of the pandemic, the economic condition of central authorities and public transport providers, and the governance of public transport services.

The second set of recommendations emphasizes the need to push forward our understanding of the role of differences in travel behavior in the evolution of a pandemic and the disproportionate consequences experienced by minorities. The lack of recent travel modal split data, together with other limitations, represents a significant limitation to this study. Therefore, it is suggested to repeat this study once the latest data on modal split (during the pandemic) is available. Additionally, the author suggested having a deeper look into the role of spatial and environmental conditions on the higher incidence of Covid-19 infections among ethnic minorities and the relative role of disparity in employment background.

# List of Figures

# List of Tables

# Table of Contents

# 1. Introduction

## 1.1. Problem Definition

TwentyTwenty has been a year whose rhythm has been dictated by the arrival of a new severe acute respiratory syndrome, later denominated as Covid-19. The virus, first detected in December in Wuhan, China, swiftly spread across the globe within weeks, triggering an unprecedented pandemic with arduous implications. As the number of infections and deaths inflated in every corner of the world, governments quickly mitigated by imposing social-distancing, widespread lockdowns, and travel bans. The unstoppable march of the novel virus, combined with the austere series of mitigative interventions, had severe socio-economic implications. World economies plummeted - with Netherland's GDP falling by -9.4% in the second quarter of 2020 (CBS, 2020) - affecting most economic sectors, with transportation being one of the biggest victims. Moreover, the pandemic had and still has severe social ramifications. One of the primary consequences was the sudden surge of unemployment that left people at the mercy of savings and stimulus checks, followed by the daunting worsening of mental health - caused by isolation, social-distancing and fear of infection (Płomecka et al., 2020) - and gender inequality (Vidyakant & Appasani, 2020).

Furthermore, the Covid-19 pandemic seems to have deepened the multidimensional disparity that polarizes the socio-economic and living conditions of ethnic minorities groups and their white counterparts. Covid-19 has proved to be a disproportionate burner for ethnic minorities in infections and fatalities numbers (Schmitt-Grohé, Teoh & Uribe, 2020), exposing society's deep and chronic health and social unfairness. The witnessed health disparity and differences in healthcare outcomes have been initially linked to fracturing differences in socio-economic status (SES), structural inequality, and segregation (Yaya et al., 2020). However, with an evolving better scientific understanding of the nature of the Covid-19 pandemic, few scientists also indicated the public transport sector and differences in travel behavior as another potential igniter of biased infections rates (McLaren, 2020). A major source of scrutiny was the public transport sector, that despite broad restricting measures and widespread paranoia that halved daily ridership (De Vos, 2020; Kim et al., 2017, Sadique et al., 2007), it continued to function as a mobility lifeline for the remaining commuters, essential workers, white collars workers, ethnic minorities, and people from a low socio-economic background. These people, which did not have access to private means of mobility (e.g., car), had no choice but to use public transportation during the pandemic, where for personal and contextual reasons, it is increasingly difficult to practice physical distancing than in the private comfort of cars (Bird & Tsivanidis, 2020).

The role that travel behavior plays in affecting an individual's health and the idea that public transport might be a leading contributor to the ramifications of a pandemic is not a novelty. In the past, researchers have shown the mediating role that public transport (e.g., air travel and public transport) played in the dissemination of previous infections diseases (Muley et al., 2020; Charu et al., 2017; Kim et al., 2010; Brownstein et al., 2006; Merler & Ajelli, 2010; Khan et al., 2009). Moreover, there is extensive U.S.-based research on how disadvantages in travel behavior might have impacted the health of minorities and the poorer (Sánchez et al., 2003). However, the unprecedented conditions of the Covid-19 pandemic and the socio-political upheaval around racial inequality in which the pandemic developed created unique conditions that crystallized the toxic relationship between ethnicity, travel behavior, and the consequences of a pandemic that resulted in the overrepresentation of Covid-19 infections among ethnic minorities. The pandemic

offered a unique opportunity to unveil the actual socio-economic and policy-related reasons that hampered societal fairness and helped to reassess our understanding of these issues. In fact, the notion that blames public transport as a super-spreader is being challenged by a growing body of research aimed at debunking it together with the policy measures used to restrict it (Berrond, 2020; Gkiotsalitis & Cats, 2021; Islam et al., 2020; Haug et al., 2020). Furthermore, more researchers are seeking to understand the key drivers behind the unfair health outcome experienced by ethnic minorities. However, both relevant fields of research remain untapped, representing a major limitation to delineating an efficient and diligent policy intervention aimed at enhancing fairness and resiliency in the transport sector and safeguard the safety of ethnic minorities.

## 1.2. The importance of Ethnic Orientation in This Study

Transport-based studies cannot be freed from a discourse on ethnicity. Society and its socio-economic and political progression are riddled with inequalities. The transport policies that in recent decades have led society to be radically interconnected, through the development of highways and public transport networks, have directly and indirectly structured society's travel behavior on the basis of the haves and have-nots. The consequences are that, as thoroughly described by Sánchez et al. (2003), in dominant white cities intrinsically structured by racial segregation where the poverty rate is disproportionally dominant among ethnic minorities, public transport users are predominantly minorities with low to moderate income. Hence, our understanding of transportation deeply intersects with race, poverty, and geography.

This intersection became even more evident with the arrival of the Covid-19 pandemic. The crisis urged people to adapt their travel behavior to the evolvement of the pandemic and the stringency of policy measures. However, the ability to do so, once again, varied between the haves and the have-nots. People with access to a vehicle diverged from crowded public transport (Ezike & Burrowes, 2020), while the economically worse-off individuals, usually being the ethnic minorities (Bird & Tsivanidis, 2020; Yaya et al., 2020), could not and continued to use the stigmatized and presumably unsafe public transport (McLaren, 2020). The question that motivates the inclusion of ethnicity in this study is:

*This disparity in travel behavior results from conscious differences in an individual's will, or is the result of pre-existing socio-economic, geographic, and health circumstances beyond the control of the individual they influence?*

The response to this can be derived from the impact that race or ethnicity can have on an individual. According to Karner et al. (2016) and many more transport researchers, “the race and ethnicity of a traveler is likely to affect the transportation resources available to them and the decisions they make regarding the amount of travel they undertake and the mode they use to undertake it”. Consequently, ethnic minorities are inherently hindered from adapting their travel behavior as their white counterparts did throughout the pandemic. Furthermore, to understand the real nature behind the role of travel behavior in the evolvement of the Covid-19 pandemic, ethnicity and its influence must be considered. Not doing so will veil the truth in the relationship between transport and Covid-19 and will continue to deepen the disparity between those who have and the ethnic minority known to have not.

## 1.3. Research Gap

Firstly, much research on the over-representation of ethnic minorities among Covid-19 infections and deaths has been carried out in the United States and in the United Kingdom, where there is significant availability of data collected and reported on ethnic minority populations, and the structural ethnic disparity has caused socio-political upheaval in search for answers and solutions. On the other hand, most European countries, including the Netherlands, are reluctant to collect and stratify health data on ethnic grounds to avoid discrimination. According to Docteur & Berenson (2014), there are cultural, political, and historical reasons for these markedly different lenses through which the U.S. and the EU view data collection based on ethnic background. The United States, marked by the legacy of slavery and discrimination, has adopted a racially oriented perspective on certain social concerns to ensure societal fairness and uplift the socially disadvantaged. In Europe, experience with the level of discrimination witnessed during WWII has caused hesitation to segment the population on ethnic grounds, leading European state members not to collect data on race and ethnicity (Docteur & Berenson, 2014; Simon, 2001; Ringelheim, 2009). Although in the Netherlands, some exemptions allow data collection on ethnic minorities - for example when in In 2015 the NISR research on discrimination on the grounds of ethnic background in job applications in The Hague (Adriessen, 2015) - it remains largely stigmatized, resulting in hospitals avoiding registering patient's ethnic background data at admission (van Heerde, 2020). As a result, in the Netherlands, few studies acknowledge the disproportionate burner experienced by ethnic minorities during Covid-19 (Kuyper & Putters, 2020; CBS, 2020), and only a few news outlets led studies have sought to identify the main drivers instigating this disparity (RTL Nieuws, 2020; van Heerde, 2020).

Secondly, when it comes to ethnic disparity traced back to behavioral differences in mobility during a pandemic, the number of explorative researches becomes scarce. Few studies conducted in the United States identified public transport as a key driver of the higher incidence of Covid-19 infections among ethnic minorities (McLaren, 2020) and demonstrated that a reduction in mobility and public transport usage varied by income, with wealthier areas decreasing mobility significantly more than impoverished areas (Weill et al., 2020; Bird & Tsivanidis, 2020; Yaya et al., 2020). This type of research is absent in the Netherlands, except for a longitudinal study conducted by de Haas (2020) to investigate the shift in travel behavior in the Netherlands due to the pandemic and nationwide restrictive measures. However, this study omitted to segment respondents by ethnic background, impeding an understanding of how different ethnic groups' travel behavior mutated due to the pandemic. Once again, the same reasons that limited studies on the ethnic disparity in health care outcomes can be applied to the lack of Netherland-specific studies on the ethnic disparity in travel behavior. At the same time, findings from U.S.-based studies can not be directly translated to explain the similar disproportionate incidence of Covid-19 infections and death among ethnic minorities in the Netherlands. This is because the United States and the Netherlands have distinct ways of governing their political and economic institutions, different social paradigms, and welfare states.

Thirdly, the literature review on the relationship between ethnic disparity, the disparity in travel behavior, and over-representation Covid-19 among ethnic minorities (*Chapter 2.5., 2.6. & 2.7.*) demonstrates that these two research areas are ill-linked. Only one study conducted in the United States by McLaren (2020) - aimed at detecting the socio-economic roots of ethnic disparity in Covid-19 records - took into consideration income, poverty rates, education, occupation, access to healthcare insurance, and commuting patterns to provide an overarching understanding of key drivers in the witnessed ethnic disparity. More specifically, this research gave an insight into the

relative impact of travel behavior as a cause of ethnic disparity in health care outcomes compared to other socio-economic and demographic variables. However, no studies of this kind have been conducted in Europe or Netherlands, and as mentioned earlier, such findings cannot be generalized and translated to provide an answer to Netherlands' ethnic disparity during Covid-19.

## 1.4. Problem Statement & Research Objective

The identified research gaps highlight the lack of Netherlands-specific studies on the observed ethnic disparity during the Covid-19 pandemic that takes into consideration not only socio-economic & health care disadvantages and poor living conditions but also ethnic group's shifting travel behavior and the degree of exposure to the virus. This multidimensional research gap can be translated into the following problem statement:

> Currently, there is insufficient knowledge on the relationship between ethnic background, differences in socio-economic, health & living characteristics, differences in travel behavior, and Covid-19 infections & deaths to shed light on the disproportionate effect of Covid-19 on ethnic minorities in the Netherlands.

To contribute to the tussle against systematic racisms and to the search for fairness in health and transportation during a pandemic, this thesis aims to provide a comprehensive understanding to what extent disparity in travel behavior is a key driver behind the over-representation of ethnic minorities among Covid-19 infections and deaths. Understanding how travel behavior has contributed to the daunting incidence of Covid-19 among disadvantaged minorities is a paramount piece of information for policy-makers and public transport providers to firstly understand the source of this social issue and then to reflect on potential mitigative interventions to safeguard the well-being of ethnic minorities. This nationwide study will also aim to compare the role of travel behavior as a mediator between ethnic background and Covid-19 records, with other variables that could also explain this relationship, such as socio-economic characteristics, living conditions, and health conditions of different ethnic groups.

Additionally, this study intends to utilize findings to diligently convey recommendations for both policy-makers and public transport providers in the Netherlands on how to potentially mitigate the implications that public transport might have on the ethnic disparity in healthcare outcomes and on how to best adapt the transport sector to such unprecedented health crises to diminish their socio-economic implications. For this purpose, following the analysis' results, special attention will be given to analyzing the current status quo of existing transport-related policies and measures adopted throughout the Covid-19 pandemic, assessing their effectiveness in curbing discriminatory infection and death rates. Lastly, based on this study and policy analysis results, policy interventions will be outlined to enhance fairness and resilience in the transport sector.

This research might improve our understanding of the role of travel behavior in relation to the morbidity and mortality of an infectious disease in the Netherlands, and it can elucidate which and why specific groups are at higher risk during a health crisis. In conclusion, findings could help reduce disparities that have conditioned the well-being of ethnic minorities and improve the resilience of the Dutch transport sector in future health crises.

## 1.5. Research Questions

Based on the problem statement, the main research question of this study is formulated as follows:

> To what extend disparity in travel behavior is influencing the disproportionate incidence of Covid-19 infections and deaths among ethnic minorities? And how can policy-makers and public transport providers best adapt public transport to future discriminatory health crises?

It is imperative to specify the meaning of the term "disparity in travel behavior" to understand the main research question fully. By "disparity in travel behavior" it is meant the differences in travel patterns between ethnic groups during the Covid-19 pandemic caused by socio-economic & living disadvantages, and inability to abide by the imposed institutional restrictions & practice social-distancing that bound specific ethnic groups to use public transport and have a higher degree of exposure to the virus. It is also important to re-state that the role and influence of disparity in travel behavior as a mediating variable between ethnic background and Covid-19 records will be compared to disparities in socio-economic, living, and health conditions to fully comprehend its relative role in this relationship and inherent preferences in travel mode for different ethnic groups.

The identified main question can not be resolved straightforwardly. It embodies a variety of sub-research components that ought to be discretely identified and resolved. The followings are the sub-questions that shall be answered in the spirit of answering the main research question:

*Table 1 - Overview of research questions and associated research methods*

| # | Sub-Research Question |
|---|---|
| **1** | What are the demographic, socio-economic, living, health, and travel behavior differences between ethnic groups in the Netherlands? |
| **2** | How does the travel behavior of ethnic non-Dutch minorities differs from their Dutch counterpart? |
| **3** | What is the relationship between different mobility patterns and Covid-19 infections and deaths rates in the Netherlands? |
| **4** | What is the relationship between ethnic non-Dutch minorities & Dutch natives and Covid-19 with their travel behavior as a mediating variable? |
| **5** | To what extent is travel behavior influencing Covid-19 records compared to socio-economic, living, and health conditions? |
| **6** | How can policy-makers and public transport providers best mitigate health disparities and the socio-economic implications brought by the Covid-19 pandemic? |

Firstly, the research will start with the identification of the ethnic composition of the Netherland's population and will use literature on the difference between ethnic groups based on demographic, socio-economic, living, health condition, and travel behavior to detect the type of variables that will be used for this study (*sub-question 1*). Once the determinants have been formulated, the study will thoroughly analyze their relationship. It will analyze the relationship between ethnic background and mobility patterns to understand ethnic groups' differences in travel behavior (*sub-question 2*). Next, it will understand the relationship between different mobility patterns and

Covid-19 infections and deaths records (*sub-question 3*). This will give us an isolated understanding of how different means of mobility are related to Covid-19 records. In the fourth sub-question, this study will examine the relationship between ethnic background and Covid-19 with differences in travel behavior acting as a mediating variable (*sub-question 4*). Afterward, this study will provide an aggregate analysis of the role of travel behavior as a mediating variable (between ethnic background and Covid-19 infections and deaths rates) in relation with other mediating variables (socio-economic, living, and health conditions) that could have also explain the higher incidence of Covid-19 infections and deaths among ethnic minorities. (*Sub-question 5*). The outcome of the analysis will be used to confirm whether or not a disparity in travel behavior plays a role in the overrepresentation of Covid-19 cases among ethnic minorities and to see if travel behavior (transport sector) influences the development of Covid-19 implications. Results will feed into a policy analysis aimed at drafting policy interventions and recommendations to mitigate best the health disparities and the socio-economic implications of the Covid-19 pandemic.

## 1.6. Thesis Outline

The rest of the thesis is conceptually aligned to provide an answer to each sub-question, and it is structured as follows. **Chapter 2** includes an in-depth review of the scientific literature used to analyze the witnessed ethnic disparity during Covid-19, the ethnic composition of the Netherlands, and the socio-economic, health, living, education, and travel behavior disparity in the Netherlands. Furthermore, it describes the relationship and causation between the mentioned variables to outline a conceptual model that will function as the guideline of this study. **Chapter 3** describes the research methods, model specifications, and related limitations. **Chapter 4** reflects on the results obtained from the developed models. It begins by elaborating on the model specification of the three models that will be used for the analysis. All models are founded on the conceptual model and the theory discussed in Chapter 2. The results will be described thoroughly and followed by a brief summary. **Chapter 5** is consequential to the nature of Chapter's 4 findings. The results will be sided by an in-depth policy analysis and actor analysis aimed at understanding the current status quo of transport-related policy and measures adopted throughout the pandemic and assessing their effectiveness in achieving what they were designed for. This study models results and insights gathered from the policy analysis will then be used to outline policy interventions and recommendations to guarantee fairness and resilience in the Dutch transport in future health crises. **Chapter 6** reflects on the work accomplished by this study and prides a summary of this study. Moreover, it describes the recommendations tailored for policymakers and future studies. In conclusion, **Chapter 7** reflects on the research goals that guided this thesis and on its findings. It later discusses the scientific contribution and the societal and policy implications of this study. Lastly, it reflects on the limitations of this study.

# 2. Literature Review

This chapter seeks to lay down the informational foundations that will characterize this study. It will begin with an in-depth analysis of the ethnic health disparity and the travel behavior disparity registered during the pandemic, providing a zoomed view of such occurrences in the Netherlands. It continues with a description of the demographic characteristics of the Netherlands, identifying the ethnic groups that need to be considered for this study and exploring their living, socio-economic & health differences. Furthermore, it will elucidate the travel behavior characteristics of the identified ethnic groups, analyzing their differences on the basis of their socio-economic status, living conditions, car access, and cultural norms. Later, it will describe the relationship between the multidimensional ethnic disparity and Covid-19 in the Netherlands, presenting the potential variables that could have functioned as a mediator between ethnic background and Covid-19 records. These pieces of information will function as the foundation of this study, providing informative support for the conceptual model that represents the backbone of this paper. The conceptual model will provide an aggregate viewpoint toward understanding the role of disparity in travel behavior in the disproportionate impact of Covid-19 infections and deaths among ethnic minorities.

## 2.1. Methodology for the Literature Review

A pivotal component of this study is the literature review, a process aimed at gathering scientific literature to gain an in-depth understanding of the existing research pertinent to a specific topic or field of study (Western Sydney University Library, 2017). In this study, the literature review aims to develop a comprehensive understanding of the Covid-19 implications on the multidimensional ethnic disparity experienced by minorities in the Netherlands and on the actual nature of this disparity in the Netherlands. Results from the literature review will feed inputs into the conceptual model that will later function as the theoretical guideline for the rest of the study.

The author's organized the literature gathering process into six categories, namely:

- **Literature on the implications of the pandemic:** Recent literature that discusses the multidimensional ramifications of the Covid-19 pandemic. A major emphasis was given to analyzing the registered ethnic healthcare outcome disparity literature and on the bidirectional relationship between travel behavior and Covid-19 evolution. The majority of the literature consulted was U.S.-based, with little empirical evidence located in the Netherlands. The keywords used to find relevant literature were "Travel Behavior" AND "Covid-19" AND "Ethnic Disparity". The denomination of the Coronavirus pandemic is named and cited in different manners, such as "Coronavirus", "SARS-CoV-2", "Covid-19" and "Coronavirus 2". However, this literature will only use the term "Covid-19" for research.

- **Literature on socio-economic disparity in the Netherlands:** Literature research aimed at understanding the socio-economic disparity conditions in the Netherlands. The majority of the literature was based in the Netherlands, with a few coming from abroad. The keywords used to find relevant literatures were "Socio-economic" AND "Disparity" AND "Netherlands".

- **Literature on education inequality in the Netherlands:** A literature research dedicated to understanding the nature of education inequality between ethnic groups in the Netherlands, the sources of such disparities, and the implications on the socio-economic development of pupils

concerning their access to education. The keywords used to find relevant literature were "Education" AND "Disparity" AND "Netherlands".

- **Residential segregation:** A portion of literature research aimed at analyzing the differences in spatial conditions between ethnic groups in the Netherlands. It went in-depth also to understand the causes of such living disparity. The keywords used to find relevant literatures were "Residential" AND "Disparity" AND "Netherlands".

- **Health disparity:** Literature research aimed at understanding the health disparity conditions in the Netherlands, and the influence of socio-economic disadvantages on it. The keywords used to find relevant literature were "Health" AND "Disparity" AND "Netherlands".

- **Travel behavior disparity:** This key component of the literature review process focuses on examining the differences in travel behavior between ethnic groups - it can also be considered disparity since disadvantaged and minority travel behavior is most of the time not a result of their will, but of the socio-economic and accessibility opportunities which dictates their choices. It also attempts to discover the source of such differences. The keywords used to find relevant literature were "Travel Behavior" AND "Disparity" AND "Netherlands".

### 2.1.1. Literature Selection

This study gathered literature through a large number of academic databases. The main ones are the following: Google Scholar, ScienceDirect, SCOPUS. Certain filters have been applied to narrow down and validate a specific part of the research. For example, for the "Literature on the implications of the pandemic" portion of the literature study, only papers from late 2019 and 2020 have been used to identify the association between ethnicity, travel behavior, and Covid-19 infections and deaths. However, studies on previous pandemics have been used to illustrate the early relationship between those variables. The backward "snowballing" technique has been used to retrieve different studies on changes in travel behavior due to the Covid-19 pandemic from comprehensive literature reviews (Van Wee, 2015). The same technique has been used in finding relevant literature regarding ethnic disparities in test positivity rate and mortality. For the remaining parts of the literature review study, no filters have been applied to ensure that enough studies were analyzed.

## 2.2. The Infamous Relationship Between Transport and Covid-19

A highly infective pathogen significantly profits from the utter interconnectedness of present society that has been achieved through the rapid development of the transport sector - particularly the aviation industry. Millions of people travel for a personal destination on any given day, converging in airports, airplanes, train stations, trains, busses, and more. This continuous confluence increases contacts among people from distant origins and increases their exposure to various microbes that can be picked up on the journey. Afterward, travelers converted into carriers reach their destination, allowing pathogens to reach scattered and remote parts of the globe in weeks. This is the lowest common denominator that has contributed to the evolvement of the Covid-19 pandemic and its predecessors. The critical role played by the transport sector in the evolvement of a pandemic is not a novel finding. In the past, the increased number of travelers and their spatial mobility have heightened the likelihood of a global pandemic (Chen & Wilson, 2008) and directly contributed to disseminating infamous diseases (Muley et al., 2020; Charu et al., 2017). Previous studies estimated that air transport accelerated the spread of Influenza H1N1, both

within and between countries (Kim et al., 2010; Brownstein et al., 2006; Merler & Ajelli, 2010; Khan et al., 2009), and that in-flight transmission has occurred in multiple occasions (Foxwell et al., 2011; Baker et al., 2010). At the same time, the severe acute respiratory syndrome (SARS), distinguished as the first pandemic of 2021 (LeDuc & Barry, 2004), benefited from air transport to spread (Tuncer & Le, 2014). Road transport, rail transport, and public transport have also been convicted of contributing to the spread of infective diseases, with studies demonstrating that Influenza A & H1N1 transmission occurred both via road transport (Piso et al., 2011; Xu, Tian, &. Xu, 2019), via rail transport (Xu, Tian, &. Xu, 2019; Zhang, Zhang, & Liu, 2011), and also via local public transport (subway) (Cooley et al., 2011). The Covid-19 pandemic has followed similar spread trajectories of previous pandemics but in an unprecedented magnitude. In fact, within weeks, outbreaks had swept across China and continued to reach 219 countries by 2021's dawn. This makes the Covid-19 pandemic an unparallel crisis with unique implications.

## 2.3. Societal Response to Covid-19

The ferociousness of Covid-19 has urged policy-makers to diligently impose a series of non-pharmaceutical measures in the form of social-distancing, complete/partial lockdown, required/voluntary quarantining, and closure of schools and workplaces (Barbieri et al., 2020) to curb the further spread of the virus and alleviate pressure on the health-system capacity (Han et al., 2020). The introduction of mitigative measures began with China's swift and austere attempt to arrest Covid-19s' domestic spread. As the virus reached Europe, member states introduced similar measures, such as school and workplace closure, and imposed non-essential travel bans. The strictness of such measures has varied throughout the first year of the Covid-19 pandemic based on the number of infections and hospitalizations. *Figure 1* illustrates the Covid-19 government stringency index for six countries - including the Netherlands - from the January 2020 till February 2021.

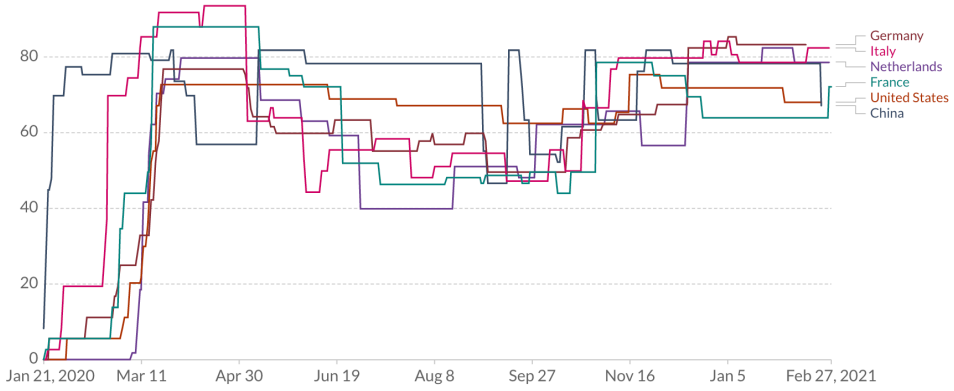



*Figure 1 - Covid-19: Government Stringency Index. Out World in Data (2020)*

Netherland's initial lenient approach quickly evolved into an "intelligent lock-down" guided by informed opinions of experts (Wallenburg et al., 2020). After quickly banning flights in and out of China and subsequently Italy, early measures prompted citizens to practice social-distancing and self-isolation in the event of a symptom, calling on people's civic duty to adjust social norms to the health crisis. Furthermore, non-essential activities, such as restaurants and bars, schools, and 'contact professions' were closed (de Haas, Faber & Hamersma, 2020). The level of intervention's

stringency deployed by the Dutch government initially fell during the summer of 2020 but then rapidly heightened as infection rates surged in fall/winter 2020/2021. New unprecedented measures were imposed, such as a curfew, which helped lessen the daily infection rate related to the new British Covid-19 variant. *Figure 2* illustrates the relationship between stringency levels and daily increases Covid-19 infections in the Netherlands.

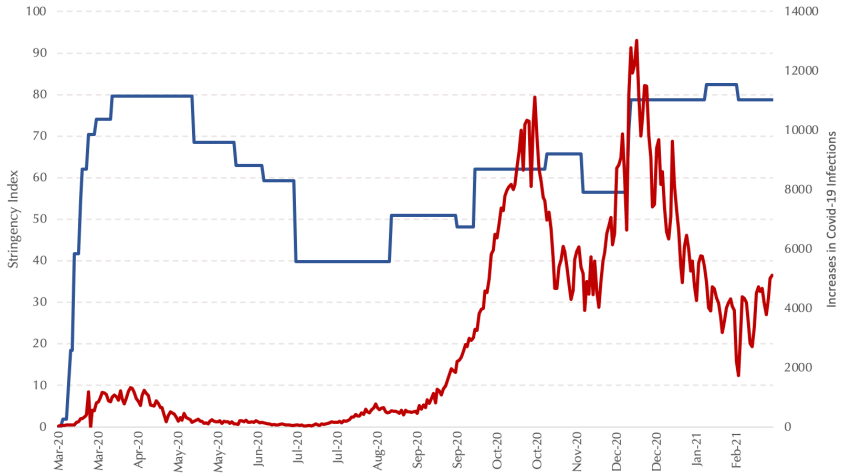



*Figure 2 - Netherlands stringency and increases covid-19 infections*

Measure's imperative role is to contain the virus, and several studies have demonstrated their relative success in doing so. China's drastic approach to curb the spread of the virus by limiting human mobility has been shown to substantially mitigate the national spread of Covid-19 (Kraemer et al., 2020). A comprehensive study conducted by Flaxman et al. (2020) has shown that major non-pharmaceutical interventions have had a significant effect in reducing transmission in Europe, and it has been estimated that "across 11 European countries, 3.1 (2.8–3.5) million deaths have been averted owing to interventions since the beginning of the epidemic". However, imposing mobility restrictions when the virus has already reached the international border will not ward off a pandemic. Studies on the impact of the mobility-related restriction on previous pandemics have attempted to raise this red flag and have empirically demonstrated the effectiveness of early mitigative measurers over late international interventions (Milne et al, 2008; Bajardi at al., 2011; Otsuki & Nishiura, 2014). Although few studies attempted to assess the implications of Covid-19 and related governmental's measures on mobility behavior in the Netherlands (de Haas, Faber & Hamersma, 2020), no studies have sought to analyze the implications on national-level infections rates.

## 2.4. The Impact of Covid-19 on Travel Behavior

Covid-19's gravity has greatly shaken risk perception related to mobility, causing behavioral changes and altering human travel patterns. Human mobility has always been directly or indirectly vulnerable to crises that would damage their welfare (Law, 2006). Events like the 9/11 terrorist attacks at New York's twin towers (Lepp and Gibson, 2003) and the SARS pandemic that shook Hong Kong and the rest of the world (Hong Kong Tourism Board, 2004) have had profound repercussions on the tourism industry and traveler's behavior for 21st century. This consequential alteration of human mobility during and after a crisis is related to travelers' shifting risk perception in relation to a specific means of transport, which is a key factor influencing their travel decisions

(Law, 2006). Moreover, studies have demonstrated that this behavioral change is related to an urge of selfish self-protection, which tends to reduce contact with the rest of the population based on risk perception (Rizzo, Frasca & Porfiri, 2014). Like previous significant crises, Covid-19 has impacted travelers' attitudes toward means of transport due to the related perceived threats to their health. Recent studies have shown that the perceived probability of getting infected is much greater for public transport rather than non-public transport (Barbieri et al., 2021). More specifically, transport modes like solo car riding and biking/walking have been deemed as the safest. In contrast, public transport (bus, tram, metro, and train), shared mobility (ride-hailing, car sharing, and shared micro-mobility), and air travel have been deemed as the most dangerous potentially due to the increased proximity among individuals (Barbieri et al., 2021; McKinsey Center for Future Mobility, 2020; Abdullah et al., 2020).

A combination of widespread paranoia, austere governmental restrictive measures, and the augmentation of transport-related risk perception has disrupted the transport sector, considered one of the most significant casualties among economic sectors (Muhammad, Long & Salman, 2020). Both voluntary and enforced behavioral changes have induced a large worldwide mobility reduction (Warren & Skillman, 2020). Administrative restrictions have shown to be particularly effective in curbing human mobility, with studies demonstrating that a lack of restriction could have resulted in a surge of daily mobility and virus circulation (Gao et al., 2020). As a result, in the months following the first Covid-19 registered case in Wuhan - January 23, 2020 - the United States experienced a 7.87% mobility reduction (Engle, Stromme & Zhou, 2020), China a 69.85% mobility reduction (Bao & Zhang, 2020), and Spain an overall reduction in mobility by 76% (Aloi et al., 2020). Among all means of mobility, public transport has experienced the deepest repercussions. Historically, people tend to avoid using public transport during a pandemic (Kim et al., 2017, Sadique et al., 2007) as a psychological response to risk (Goodwin, Gaines & Myers, 2011). At the same time, authorities have interrupted public transport services to contain the spread of the virus. As a result, people opted for safer and more reliable means of transport, such as driving and biking. Many studies analyzed the impact of Covid-19 on modes of transport. A comprehensive study from the SLOCAT Partnership on sustainable, low carbon transport that used data-sets from Google COVID-19 Community Mobility Reports and Apple's Mobility Trends Report - that included 62 countries and 89 cities in the analysis - demonstrated that requests for all transport modes have all plummeted starting from early March; however, public transport has seen the largest decline, reaching a 76% reduction in April 2020, unlike driving and walking which declined by 65% and 67% but then regained momentum after the initial drop (*Figure 3*) (Medimorec et al., 2020). Abdullah et al. (2020) used survey results from respondents from 15 countries to show that public transport usage as a primary means of transport reduced by 64% from the pre-Covid-19 levels. In contrast, private car usage and walking increase respectively by 22% and 88% from pre-Covid-19 levels. With people's travel patterns, people's travel motives and habits have also been affected by the pandemic. Due to the closure of schools, workplaces, non-essential activities, and stay-at-home administrative directions, people's behavior and habits largely mutated. Trips directed to workplaces and schools sank, leaving essential purchasing goods as the primary purpose of traveling during the pandemic (Abdullah et al., 2020; Barbieri et al., 2021).

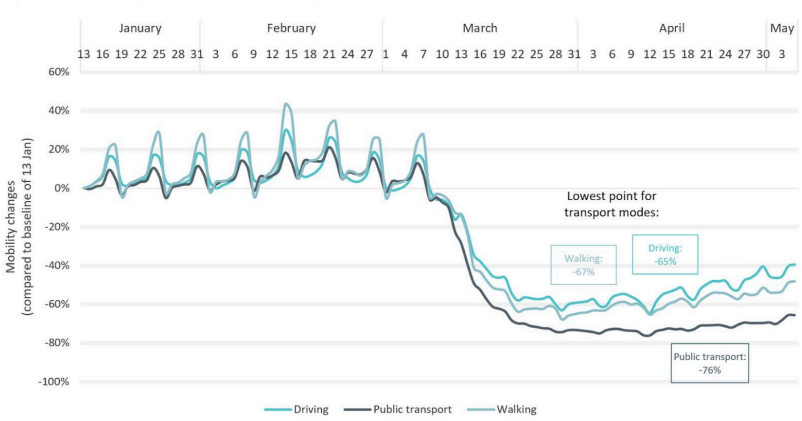



*Figure 3 - Requests for transport modes from 62 countries and 89 cities. Source:SLOCAT analysis based on Apple (2020). COVID-19 Mobility Trends Report*

## The case of the Netherlands

Netherlands's mobility trends during Covid-19 align with global levels. As shown in *Figure 4,* which illustrates Netherlands's apple mobility trends since the start of the pandemic fetched from directions in Apple Maps, public transport plummeted shortly after the introduction of stern measures and since have not yet recovered to pre-Covid-19 levels. Although driving and walking were also shaken from the initial unprecedented approach to fight this pandemic, both mobility modes quickly gained momentum and surpassed pre-Covid-19 levels, becoming primary means of mobility.

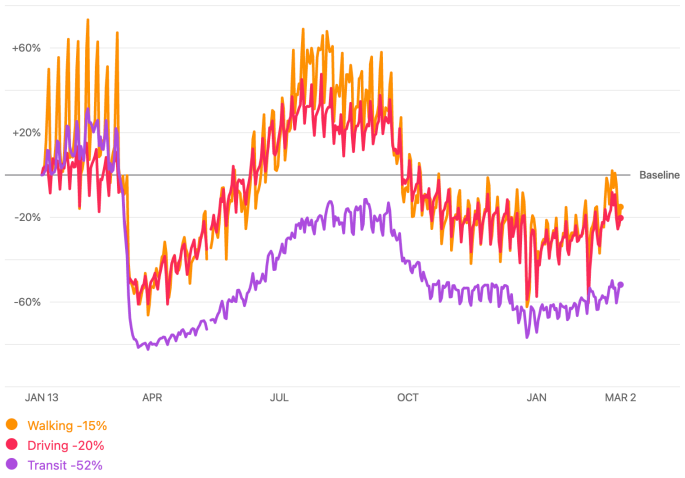



*Figure. 4 - Mobility Trends in the Netherlands during the Covid-19 pandemic. Source: Apple Mobility Trends Report (2020/2021).*

The more profound repercussions of the Dutch transport sector are linked to the targeted series of institutional measures and the shifting public's attitude towards using crowded means of transport during a pandemic. According to de Haas et al. (2020), the significant drop in public transport usage is also because people with higher education and students are more likely to study and work from home. The same study observed that during the pandemic Dutch citizens preferred, if in need, to move via biking, driving, or walking rather than shared means of mobility (de Haas et al., 2020).

## 2.5. Ethnic Disparity During Covid-19

Throughout the pandemic, researchers have been able to pin down factors that put an individual at higher risk of infections and mortality, creating a disparity in health care outcomes. Three main factors have been identified in the pandemic's early stage: age, gender, and comorbidities (Carethers, 2020). However, the pandemic has also highlighted ethnicity as a major indicator contributing to the witnessed disparity in health care outcomes (Carethers, 2020), exposing the long-lasting structural inequalities that have shaped sundry societies. In the United States, studies have reported a disproportionate incidence of Covid-19 infections and deaths among ethnic minority communities, with African Americans being 3.6 times more likely, native Americans 3.4 times more likely, Latinx (a person of Latin American origin or descent) 3.2 times more likely and Asian Americans 2.5 times more likely to die from Covid-19 than their white Americans counterpart (APM Research Lab, 2021; USA Facts, 2020; Gross et al., 2020). Among the mentioned ethnic minorities, African and Native American minorities are the most affected (Iyanda et al., 2021). In fact, The Johns Hopkins University and American Community Survey indicates that, for Black counties, the infection rate is three-fold higher than in predominantly white counties, while the death rate is six-fold higher (Yancy, 2020). This trend of ethnic health care disparity has also been registered among youngsters - even though they are less likely to suffer from Covid-19 - with Black and Hispanic Americans having higher death rates even in younger age groups (USA Facts, 2020). This disproportionate burner of Covid-19 infections among ethnic minorities is not unique to the United States. In the United Kingdom, which is also active in the study of ethnic disparity, a study showed that over 56% percent of the admitted pregnant women for infections were Black or from other ethnic minority groups (Knight et al., 2020). Although data collection and analysis on ethnic disparity is robust in the United States and the United Kingdom, it is much scarce in other developed countries like Germany or France (Tikkanen etc al., 2020). This represents a major setback from having a multidimensional understanding of the roots and implications of ethnic disparity during Covid-19 across different socio-economic paradigms.

### 2.5.1. The Causes of Ethnic Disparity During Covid-19

The cause of this disparity is a source of long-lasting debates and does not come with a simple answer. As of now, there is no clear evidence for genetic or immune predisposition for Covid-19 by race or ethnicity (Carethers, 2020). However, studies have reported that American counties with more diverse demographics were at a higher risk of Covid-19 infections (Abedi et al., 2020). This disparity is not simply due to a total fortuity of events but is attributable to variables other than simple access to health care (Smedley, Stith & Nelson, 2003). Socio-economic disadvantages are deemed as a significant driver in the degree of vulnerability to Covid-19 experienced by ethnic minorities. Studies in the U.S. have shown that counties with lower access to health insurance, higher poverty levels, and lower education levels are more at risk of infections (Abedi et al., 2020;

Wiemers et al., 2020), and very often, ethnic minorities are the ones facing multidimensional poverty and living in poorer counties (Yancy, 2020). Furthermore, being part of a low socio-economic group limits access to quality health care, developing the necessary conditions for psychological distress, alcoholism, chronic obstructive pulmonary disease, and obesity (Yaya et al., 2020). The presence of comorbidities represents another major risk factor for Covid-19. Wiemers et al. (2020) found that the prevalence of comorbidities increases with age and among ethnic minorities, with Black and socioeconomically disadvantaged individuals showing the highest prevalence of multiple comorbidities compared to White Americans, making them significantly different more vulnerable to Covid-19.

Another key condition that aggravated this disparity in Covid-19 vulnerability is the degree of exposure to the virus. Governments deemed social-distancing necessary to contain the virus; however, abiding by the imposed restrictions on social-distancing, telecommuting, and working from home are issues of privilege (Yancy, 2020). While some occupations, generally more compensated, have been quick at transferring to remote working, others that required a higher degree of physical proximity were not. Studies have found that essential workers, such as logistics and manufacturing employees and other minimum wage occupations, were less likely to engage in preventive behaviors, such as social-distancing that limit the spread of disease (Papageorge et al., 2020; Stafford, Hoyer & Morrison, 2020). The issue is that workers in these occupations are less likely to have a college degree, less likely to have health insurance, less likely to be white, and more likely to be from ethnic minorities (Mongey, Pilossoph & Weinberg, 2021). Living conditions are another key factor in the disproportionate exposure to the virus for a specific population segment. In fact, studies have shown that ethnic segregation is an important driver of mortality and infection rates (Torrats-Espinosa, 2021). Differences in socio-economic conditions and ethnic background have always induced residential segregation in most developed countries, including the United States (Williams & Collings, 2001) and the European Union (Tintori, Alessandrini & Natale, 2018). Historically it has been demonstrated that ethnical residential segregation is linked to differences in public transport access (Tintori, Alessandrini & Natale, 2018), mortality and life expectancy, and incidence of diseases among ethnic minorities (D. Acevedo-Garcia, 2001); and Covid-19 has crystallized its role in the spread and disparity in health care outcomes. As a result, higher exposure to Covid-19 was inevitable for individuals from ethnic minorities and low socio-economic groups, making them a particularly vulnerable segment of the population.

## 2.6. Ethnic Disparity in Travel Behavior During Covid-19

Although socio-economic disadvantages, health care access, and living conditions have been known to dictate ethnic disparity, recent studies have found that a significant portion of Covid-19 related health disparity can be sourced from the use of public transport (McLaren, 2020). During Covid-19, changes in mobility have been sprung not only by enforced restrictive measures - especially targeting public transport - and altered risk perception related to mobility as described in *chapter 2.3.,* but also from the capacity of choosing an alternative transport mode. Occupations that swiftly converted to remote working have helped people abide by the imposed restrictions, minimize their mobility and prioritize essential activities, such as grocery shopping, over work-related movements (Abdullah et al., 2020). However, socio-economic disadvantaged and ethnic minorities, which are more likely to occupy less retributed occupations requiring a higher degree of physical proximity, were forced to maintain a dangerous level of mobility and commute to work. In fact, studies have shown that following social-distancing substantially varied by income, with wealthier areas decreased mobility significantly more than poorer areas (Weill et al., 2020). The ability to work from home represents ad advantage to dodge Covid-19 related implications;

however, it also represents a privilege. Ethnic minorities and poorer individuals are less likely to own a personal vehicle (Oakil et al., 2016), which is perceived as the safest mean of transport during Covid-19 (Shamshiripour et al. 2020), and are more likely to use public transport (McLaren, 2020). Thus, they are forced to commute to work by public transport during a pandemic where it is significantly more difficult to apply social-distancing (Bird & Tsivanidis, 2020; Yaya et al., 2020).

## 2.7. Ethnic Disparity During Covid-19: The Case of the Netherlands

Like other ethnically heterogeneous countries, the Netherlands has also experienced a higher incidence of Covid-19 related mortality in people with a non-Dutch native ethnic background than among Dutch natives. A comprehensive study from Kuyper & Putters (2020) for the Dutch Social and Cultural Planning Bureau confirmed that inequality is expected to grow due to the shattering pandemic and identified individuals with a migration background as one of the most vulnerable segments of the population due to common precarious living conditions, increased level of poverty, lower education levels, and because they often employed in occupations that require a higher degree of physical proximity. In May 2020, the Centraal Bureau voor de statistiek (CBS) - a Dutch governmental institution that gathers and analyzes statistical information about the Netherlands - published a study that registered for the first six weeks of the pandemic an increase of 47% for the mortality rate among non-Western ethnic minorities, such as Turkish and Moroccans, from previous year levels, while it "only" increased by 38% among Dutch natives (CBS, 2020). Another study from the Dutch news outlet RTL Nieuws analyzed the infection rates across 39 neighborhoods of the four biggest cities in the Netherlands - Amsterdam, Rotterdam, Den Haag, Utrecht - and found that many of the neighborhoods that registered a higher number of infections are largely populated by low socio-economic groups, with lower level of income, education, and with non-Dutch native background (RTL Nieuws, 2020). The case of Amsterdam represents a crystal clear snapshot of the Covid-19 related ethnic disparity experienced in the Netherlands. The datasets fetched from the Gementee Amsterdam on the city's eight district socio-economic characteristics and population composition, together with the positive test ratio findings - the percentage of positive tests out of all completed Covid-19 tests - for each of Amsterdam's district gathered from an RTL Nieuws study enables us to elucidate the incidence of Covid-19 infections among poorer, ethnically segregated and densely populated districts. As shown in *Table 2,* the Nieuw-West (F) and Zuidoost (T) districts, which house a large cluster of non-western ethnic minorities - Surinamese, Antillean, Turkish Moroccan, and other non-western minorities - are the two districts with the lowest average personal income and disposable income per household, and have also registered the highest number of positive tests out of all carried out tests in October 2020. On the other hand, districts predominantly populated by Dutch natives, the wealthiest of all districts, have registered the lowest percentage of positive tests, suggesting that the virus disproportionally impacts socio-economic disadvantaged and ethnic minorities in the Netherlands. The table also shows the incidence of Covid-19 positive tests among districts with higher occupancy levels per household which are disproportionally populated by non-western ethnic minorities.

*Table 2 - Amsterdam's eight districts demographics, socio-economic conditions and percentage of positive Covid-19 tests*

| | Percentage of Positive Test | Dutch Native (%) | Western Ethnic Minority (%) | Non-Western Ethnic minority (%) | Average personal Income (x1000 euro) | Average Disposable Income per Household (x1000 euro) | Average Occupacy per Household |
|---|---|---|---|---|---|---|---|
| **A Centrum** | 7.90% | 46.6% | 24.2% | 29.3% | 44.9 | 44.9 | 1.57 |
| **B Westpoort** | - | 42.9% | 19% | 38.1% | 26.1 | 23.5 | 3.42 |
| **E West** | 8.70% | 36.2% | 16.4% | 47.4% | 36.1 | 37.5 | 1.89 |
| **F Nieuw-West** | 13.40% | 20.8% | 10% | 69.2% | 29.1 | 36.1 | 2.37 |
| **K Zuid** | 7.40% | 45.1% | 21.4% | 33.5% | 49.0 | 49.8 | 1.83 |
| **M Oost** | 7.90% | 37.1% | 14.1% | 48.8% | 37.5 | 42.1 | 2.09 |
| **N Noord** | 8.80% | 35% | 9.5% | 55.5% | 28.5 | 35.8 | 2.51 |
| **T Zuidoost** | 17.30% | 15.2% | 7.1% | 77.6% | 25.7 | 31.4 | 2.12 |

*Source: "Percentage of Positive Test" (RTL Nieuws, 2020); Rest of the variables (Gementee Amsterdam, 2020)*

Generalizing these findings to the entire country is not an easy matter. First of all, Amsterdam is among the biggest and most diverse cities in the Netherlands, both characteristics that render it an exceptional hotspot for Covid-19 to flourish (Sharifi & Khavarian-Garmsir, 2020); however, many urban areas in the Netherlands are not as ethnically heterogeneous and densely populated, representing different characteristics from Amsterdam. A major issue that restrains researchers from understanding to what extent Covid-19 victimizes socio-economic disadvantaged individuals and ethnic minorities in the absence of in-depth nationwide health care data on ethnic minorities (van Heerde, 2020). In other countries, such as the United States and the United Kingdom, much more data on ethnic minorities concerning Covid-19 records is at the researchers' disposal, enabling to ferret out the latent racist behavior of Covid-19 and the socio-economic drivers that favor it. According to Johan van Heerde (2020), a journalist from Trouw (Dutch news outlet)" registering ethnic related data is a sensitive issue in the Netherlands". Although the Dutch National Institute for Public Health and the Environment (RIVM) understands the benefits of including ethnicity in health care data collection to investigate discrimination in health care, the majority of the hospitals bypass registering patients' ethnicity to safeguard their privacy (van Heerde, 2020). Another barrier, according to Karien Stronks - professor of public health at the University of Amsterdam - is ethnic minorities' tendency to refrain from participating in medical researches, making them less represented than their Dutch native counterpart.

## 2.8. Ethnic Disparity in Travel Behavior: The Case of the Netherlands

As described in Chapter 1.3.1., Mobility data from Apple's mobility trends report and Google's Covid-19 community mobility reports allows us to understand the impact of Covid-19 on public and private transport ridership and people's shift in mobility motives in the Netherlands. Besides these aggregate public datasets, which do not provide insights into differences in mobility response

among ethnic groups, few studies have attempted to assess the impact of Dutch's travel behavior, and none have sought to bring to the surface the ethnic disparity that is sourced to the use of public transport during a pandemic in the Netherlands. Only three major studies have attempted to elucidate the impact of widespread anxiety, changes in transport-related risk perception, and Netherlands's "intelligent lockdown" on travel behavior (de Haas et al., 2020; de Haas et al., 2020; Kuiper et al., 2020). However, only Kuiper's (2020) study has included ethnic background diversity in the study - although the number of ethnic minorities participating in the study was a small percentage compared to their Dutch-native counterpart - without finding any major behavioral deviation among ethnic groups in compliance with Covid-19 measures and mobility. As a result, ethnic disparity sourced to differences in travel behavior is ill-known in the Netherlands due to the lack of ethnic-related data in health care and mobility and the lack of Netherlands-specific studies.

## 2.9. The Nature of Ethnic Inequality in the Netherlands

### 2.9.1. Netherland's Growing Ethnic Diversity

The Netherlands is one of the most ethnically diverse countries in Europe, initially due to the great labor migration, which began in the '60s and prolonged till the late '90s, that brought hundreds of thousands of guest-workers from Turkey, Suriname, Morocco, and other countries. Although labor migration ceased to be a key factor behind migration influx, migration towards the Netherlands did not end. In the last decades, the number of political asylum seekers that wanted to enter the Netherlands permanently increased drastically; at the same time, the increasing economic & living attractiveness of the Netherlands brought thousands of people, identified as highly skilled employees, from neighboring countries and the United States, contributing to the growing ethnic variety in the Netherlands (Turton & Gonzalez, 2000). As a result, in 2020, 24.2% of the population was of immigrant origins, which has increased yearly since then, as shown from the 2019 levels (23.6%) and the 2018 levels (22.6%) (Statistics Netherlands, 2018-2020). The expression 'immigrant origins' is an umbrella term that identifies someone who has either a first-generation (born abroad) or second-generation (at least one parent born abroad) immigrant origin. The sheer size of ethnic diversity in the Netherlands - with a study determining the presence of over 30 ethnic groups with a population of over 1000 people (Turton & Gonzalez, 2000) - complicates the possibility of conducting a comprehensive study that embraces every ethnic group. Thus, this study will merely take into consideration the most populous ethnic groups. Several ethnic-oriented Dutch studies (Haustein, Kroesen & Mulalic, 2020; Turton & Gonzalez, 2000; Harms, 2008; Bos, Kunst & Garssen, 2005; Guiraudon, Phalet & Ter Wal, 2005) an annual national census (*volkstelling*) classify the population in three categories: Dutch native origin, Western immigrant origin, Non-Western immigrant origin. The western immigrant group, which represents 43.3% of the people with immigrant background (2020), is constructed 8.15% by people from central and eastern European countries, 4% southern European countries, and 31.2% by any other western countries (United States, Australia, Japan, Indonesia, etc.). The non-western immigrant group is the most populous ethnic cluster entailing 56.7% of the total number of people with an immigrant background. Turkish origins (9.9%) and Morocco origins (9.7%) constitute the biggest non-western ethnic minorities, followed by Surinamese origins (8.4%) and by Antilles & Aruba (3.9%). The remaining 24.7% of the people with an immigrant background have other non-western origins (Asia, Africa, South America, etc.). *Table 3* provides an overview of the demographic characteristics of the Netherlands in 2020.

*Table 3 - Overview of Netherlands Demographic characteristics (2020)*

| | | # Population | % of the total population | % of the total population with immigrant origins |
|---|---|---|---|---|
| **Total Population** | | 17,407,585 | - | - |
| **Dutch Native origin** | | 13,186,880 | 75.8% | - |
| **Population with immigrant origins** | | 4,220,705 | 24.2% | - |
| **Western immigrant origins** | **Total western immigrant origins** | 1,828,645 | 10.5% | 43.3% |
| | **Central and Eastern European countries in the EU** | 343,984 | 1.98% | 8.2% |
| | **GIPS countries in the EU** | 166,031 | 0.95% | 3.9% |
| | **Other western migration background** | 1,318,630 | 7.58% | 31.2% |
| **Non-western immigrant origins** | **Total non-western immigrant origins** | 2,392,060 | 13.7% | 56.7% |
| | **Morocco** | 408,864 | 2.35% | 9.7% |
| | **(former) Ned. Antilles + Aruba** | 166,265 | 0.96% | 3.9% |
| | **Suriname** | 356,402 | 2.05% | 8.4% |
| | **Turkey** | 416,864 | 2.39% | 9.9% |
| | **Other non-western** | 1,043,665 | 5.99% | 24.7% |

*Source: Statistics Netherlands (2020)*

The breakdown of the Netherlands's demographic illustrated in *Table 3* is used to select and group the ethnic groups that will be used in this study. For this study, the ethnic background section will be divided into three main groups: Dutch native origin, western immigrant origins, and non-western immigrant origins. In order to acquire a more detailed understanding of the overrepresentation of ethnic minorities among Covid-19 records and fatalities rates in the Netherlands, this study includes the various ethnic minorities that constitute the non-western immigrant origins group (Morocco, (former) Ned. Antilles + Aruba, Suriname, Turkey, other non-western). It is important to mention that the three ethnic sub-groups that form the western immigrant origins group are not included due to the lack of ethnic-specific data in their regards. However, this is something that will later be discussed in depth in Chapter X.

### 2.9.2. Socio-economic disparity

Socio-economic disparity has a deteriorating impact on affected communities, limiting the opportunity for an economic, living, and educational uplift (Thorbecke & Charumilind, 2002). Socio-economic disparity is a common trait among developed and ethnically diverse countries, and it is the result of centuries of radicalized racism and colonialism that shaped the existing

conditions for structural inequality. The level of disparity varies among countries, albeit most are not exempt from living with and managing this plague. The Netherlands is one of them. Although income inequality in the Netherlands is relatively low by European Standards (Afman, 2020) and it has the most egalitarian income distribution within the EU, it is experiencing a growing income & wealth inequality where the top 20% of the population earn about four times as much as the bottom 20% (OECD) and the top 10% wealthiest households own roughly two-thirds of total net wealth (Afman, 2020), making the Netherlands the second country with the highest wealth inequality after the United States (OECD 2018). This considerable gap disproportionally impacts the poorest segment of the population, primarily composed of ethnic minorities, which generally have a lower socio-economic status (Bos, 2005). According to the latest report on the distribution of the wealth of private households in the Netherlands by Statistics Netherlands (2019), non-Dutch native citizens have a considerably lower income, with non-western immigrants earning the least among all ethnic groups. People with non-western immigrant origins also experience a higher poverty level, with 23.4% of the non-western immigrant households having an income below the low-income threshold. While income inequality has generally been increasing in the last decades (Salverda et al., 2013), the situation differs between ethnic groups, with people with immigrant origins experiencing a higher level of both income and wealth inequality. This is illustrated in *Table 4*.

*Table 4 - Ethnic group's socio-economic status in the Netherlands*

| | Average Disposable Income (euros) | Average Standardized Income (euros) | Median Power (%) | Low-Income Households (%) | Income Inequality (Gini Coefficient) | Wealth Inequality (Gini Coefficient) | Unemployment rate (%) |
|---|---|---|---|---|---|---|---|
| **Dutch native origins** | 46,300 | 32,100 | 78.4% | 5.3% | 0.279 | 0.729 | 3.1% |
| **Western immigrant origins** | 40,800 | 29,400 | 17.2% | 9.1% | 0.331 | 0.813 | 5.1% |
| **Non-western immigrant origins** | 34,500 | 23,300 | 1.2% | 23.4% | 0.299 | 0.884 | 8.7% |

*Source: Statistics Netherlands (2019)*

Employment is a significant determinant of socio-economic disparity. People with stable jobs are generally less vulnerable to experience multi-dimensional poverty. In the Netherlands, people with a migrant background are more likely to be unemployed, and the situation worsens for people with a non-western immigrant background (Van den Bossche, 2019). In fact, the unemployment rate for the mentioned group reaches 8.7%, well above the national average of 4.0% and Dutch native's level (3.1%). The issue is that even having a job no longer secures people from risking poverty. As Van den Bossche (2019) explains, the 'working poor' segment, employed households that experience poverty, is an ever-growing group pushing thousands of employed migrant families to the brink of poverty.

### 2.9.3. Education Inequality

Another major fount of socio-economic disparity in the Netherlands is education. Education is often deemed as the panacea for all inequalities, as it plays a crucial role in securing economic and social betterment and ameliorating income distribution (Ozturk, 2008; Burchi, 2006). In the Netherlands, the growing opportunity gap in education underlines the socio-economic disparities that jeopardize social amalgamation. Households' financial situation heavily dictates the educational path interpreted by young students. In fact, pupils with low-income and less-educated parents are often enrolled in VMBO (pre-vocational secondary education) dedicated to directly preparing students to enter the blue-collar job market. Contrarily, children of higher educated and Dutch-native families are more likely to be enrolled in HAVO (higher general continued education) and VWO (preparatory scientific education), both programs that lead to higher-level education (university) (Ministers van Onderwijs, Cultuur en Wetenschap, 2019). The educational disparity continues even at the higher education level, with people with non-western immigrant origins being less likely to hold both an HBO (university of applied sciences) and WO (academic university education) diplomas. Holding a university degree (WO) ensures access to higher-paying jobs, often defined as white-collar, and guarantees higher degrees of job security compared to pupils holding a VMBO or HBO diploma. These differences in educational conditions are vivid sources of inequality that impede establishing a level playing field in both education and employment to uplift vulnerable segments of the population. People with immigrant origins, especially from non-western countries, are disproportionally conditioned by this disparity - studies show that the probability of not having a job one year after graduation is 23 percent for graduates with a non-Western migration background and 14 percent for graduates without a migration background (Ministers van Onderwijs, Cultuur en Wetenschap, 2019) - and thus are forced to occupy unstable low-paid blue-collar positions.

### 2.9.4. Residential Segregation

One of the negative ramifications of the migration influx that characterized the last fifty years is residential segregation. The heterogeneous settlement patterns of incoming ethnic groups influence socio-economic integration, inter-ethnic contact, and social cohesion (Pinkster, 2008; Sleutjes, de Valk & Ooijevaar, 2018). In addition, residential segregation is a key indicator of socio-economic disparity. In the Netherlands, people with non-western immigrant origin predominantly live in urban areas - with some studies estimating that over 40% of the immigrant population live in the four biggest cities in the Randstad region, while only around 11.5% of the population resides there (Turton & Gonzalez, 2000) - and cluster in districts with a high incidence of low-income households, unemployment, and high welfare dependency (Hartog & Zorlu, 2009). The witnessed ethnic residential segregation is not solely a result of endogenous conditions, such as cultural representation or congregation (Musterd & Van Kempen, 2009), but also on limiting exogenous factors, such as the housing market and job opportunities (Sleutjes, de Valk & Ooijevaar, 2018). As a result, most Dutch cities are divided into highly-educated and wealthy neighborhoods populated mainly by Dutch-native that are inaccessible to ethnic-minorities, are less-educated and poorer neighborhoods denoted by a high concentration of blue-collar workers, crowded households, and high level of morbidity.

### 2.9.5. Health Disparity

Ethnic minorities are not only disproportionally affected by multi-dimensional poverty (Reeves et al., 2016), but they also experience a higher level of mortality and morbidity rates. The main reason behind this is the strong relationship between lower socio-economic status and premature

mortality and multi-morbidity (Saydah, Imperatore & Beckles, 2013; Jensen et al., 2017). A study conducted by Verest et al. (2019) showed that the prevalence of multi-morbidity in most ethnic minority groups in the Netherlands was comparable to the prevalence among Dutch-natives who were one to three decades older. Minorities often experience linguistic and cultural barriers or discrimination that bars them from accessing public services, healthcare services, higher education, high-paid jobs, and affordable housing (Verest, 2019). Other studies have shown that these groups are also more likely to experience psychosocial stress and a less healthy lifestyle due to their socio-economic disadvantages, leading to a higher risk of developing certain chronic diseases (Pampel, Krueger & Denney, 2010). As a result, the confluence of socio-economic, living, and education disadvantages establish the favoring conditions for the development of comorbidities that imperil disadvantaged groups already considered at risk.

## 2.10. Disparity in Travel Behavior

Differences in travel behaviors between ethnic groups offer a perspective into the multidimensional disparity that hinders the idea of social, economic, and health equality. Previous multi-countries research demonstrated significant differences in travel behavior between people with migrant backgrounds and people with a native background. In general, the first are more likely to use public transport, while the latter are more likely to drive a car or use other private means of transport (Williams & Chacko, 2008; Tal & Handy, 2010l; Syam, Khan & Reeves 2012). In the Netherlands, individuals with an immigrant background are less likely to both cycle and drive a car compared to their Dutch native counterpart, except for individuals with Turkish origins which appear to make relatively frequent use of the car similarly to their Dutch native counterparts (Haustein, Kroesen & Mulalic, 2020; Harms, 2008). On the other hand, public transport is predominantly used by ethnic minorities, especially by non-western immigrants residing in urban areas (Harms, 2008).

### 2.10.1. The key Drivers Behind Travel Behavior Disparity

The source of ethnic disparity in travel behavior cannot be traced back to one specific factor. These differences can partly be explained by differences in social, economic, and demographic factors, such as differences in car ownership, household income, household size, living conditions, employment, healthcare, and accessibility (Haustein, Kroesen & Mulalic, 2020; Contrino & Mcguckin, 2009; Karen et al., 2019). Access to a private vehicle is a matter of privilege. As described in *Chapter 2.9.2.*, people with an immigrant background are more likely to experience multi-dimensional poverty, and as a consequence, their access to owing a car is limited by their economic fragility. Contrarily, individuals with higher incomes (which in the Netherlands are people with a Dutch native background) and households with one or more working members are much more likely to own a car compared to people with low income and small households (Oakil et al., 2016; Karen et al., 2019). Not being able to afford a practical and reliable means of transport like a car bounds people from a low-socioeconomic group and ethnic minority to use mass transport for their daily needs. Urbanization levels are also key determinants for who can have access to a private vehicle. Studies have found that car ownership noticeably increases in the least urbanized areas, such as rural towns and urban fringes, whereas it decreases in urban conurbations (Karen et al., 2019). This could be explained by the lack of transport infrastructure & services in outskirts and rural areas and the increasing presence of low socio-economic groups in highly urbanized areas. In fact, as mentioned in *Chapter 2.9.4.,* people with immigrant origins - especially non-western - predominantly live in urban areas where there are more favorable housing conditions (Turton & Gonzalez, 2000). Ethnic minorities also spend more time traveling

than their Dutch native counterpart (Harms, 2008), possibly due to their trips' slower and fragmented nature, taking away time from personal events and work.

Differences in travel behavior that could create the conditions for disparity can also be associated with different cultural norms that prompt people to develop determined travel preferences and choices (Haustein, Kroesen & Mulalic, 2020). While in some western countries like Netherlands and Denmark cycling is seen as a conventional means of transport, in other western and non-western countries, it is notoriously seen as an unpopular alternative to cars or public transport; it is seen as 'uncool', and it is stigmatized as an alternative for poorer people (Underwood et al., 2014; Belgiawan et al., 2014). According to Harms (2008), the witnessed lower cycle ridership among non-Dutch native communities in the Netherlands than their Dutch counterpart, especially for non-western ethnic minorities like Turks, might be due to a lower level of education (higher education level is associated with higher bike usage), bigger family size (bigger households are less likely to bike often), urban living setting (residing in highly urbanized areas offers public transport as a valid alternative to biking), but also to the poor image and low status of the bicycle among young people from ethnic minorities. Contrarily, cars bear a strong reputation and a lavish status, making them a distinction point between the haves and have nots. Cars have always been deemed as a medium for emancipation and to attain a higher socio-economic status; wealthier individuals have used it to access privileges designed by car-centric communities, while poorer have used it to achieve integration and freedom. In the Netherlands, cars are primarily owned by the wealthier segment of the population constituted by Dutch natives; however, it is also common among people with Turkish origins who see it as a higher status symbol, unlike the bike (Harms, 2008). Together with the social, economic, and demographic differences among ethnic groups, these cultural nuances could dictate each group's travel attitude and preferences distinctly.

## 2.11. The Relationship Between Ethnicity and Covid-19

As described in *Chapter 2.5.*, the pandemic's racist behavior has led to an overrepresentation of Covid-19 infections and deaths among ethnic minorities, shedding light on the magnitude of socio-economic, spatial, health ethnic disparity that has shaped western countries, including the Netherlands. Since evidence shows that ethnic minorities are not genetically predisposed to disproportionally contract and suffer from Covid-19 (Carethers, 2020), there are specific conditions that caused, and still do, this daunting incidence. *Chapter 2.5. & 2.6.* elucidated that socio-economic, education, living, and health disadvantages common among ethnic minorities are considered key drivers behind the disproportionate impact of Covid-19 among ethnic minorities. However, studies have also shown that disparity in travel behavior could have contributed to this social & health plague, with public transport users - which usually are ethnic minorities that experience a higher degree of multidimensional poverty (Bird & Tsivanidis, 2020; Yaya et al., 2020) - being the most hit by the respiratory disease and the institutional and economic implications resulted from any attempt to limit it.

As a result, the relationship between ethnic background and Covid-19 infections and deaths rates is not linear. This relationship could be indirectly described by socio-economic, educational, living, health, and travel behavior disparities that create the conditions for the health and economic burner felt by ethnic minorities during the pandemic. For the sake of this study, those mediator variables are grouped in four categories, namely socio-economic, demographic, health, and travel behavior (*Table 5*). Each main group's mediator variable is selected, taking into consideration two elements. Firstly, each of the socio-economic, demographic, health, and travel behavior variables is extracted from the literature review (Chapter 2) on the relationship and

implications between each of them and ethnic background, pondering on their role on the developed ethnic disparity. Hence, only ethnic sensitive variables are taken into consideration for this study. However, data paucity is another constraint to take into consideration. Besides the fact that (as mentioned in *Chapter 2.8.*) several European countries, including the Netherlands, are hesitant to collect and stratify ethnic-specific data to avoid discrimination, not all considered mediator variables are collected and publicly available in the Netherlands. *Chapter 3* will analyze in-depth the selection process and source of the considered variables for this study. *Table 5* illustrates the list and categorization of potential mediator variables that would allow to assess the indirect relationship between ethnic background and Covid-19 records and understand to what extent travel behavior is dictating this relationship compared to variables appertaining to the socio-economic, demographic, and health groups.

*Table 5 - Overview of the mediator variables used to elucidate the relationship between ethnic background and Covid-19 infection and deceases rates*

| **Mediator Variable** | **Categorization** |
|---|---|
| Average disposable income per household | Socio-economic |
| Unemployment rate | |
| Car ownership | |
| Household composition | Demographic |
| Education levels | |
| Average age of population | |
| Population density | |
| Healthcare access | Health |
| Comorbidity rate | |
| People with a chronic disease | |
| Train | Travel Behavior |
| Public transport (bus, tram, & metro) | |
| Car | |
| Biking | |
| Walking | |

## 2.12. Conceptual Model

This study rests on the hypothesis that disparity in travel behavior might have contributed to the disproportionate impact of Covid-19 among ethnic minorities. To the best of the author's knowledge, only McLaren (2020) identified public transport usage as a source of Covid-19 induced health disparity, indicating a thread of truth in the hypothesis. However, the lack of holistic ethnic-specific studies on ethnicity, travel behavior, and Covid-19 records - especially in Europe - results in a knowledge gap that conceals the truth from the resolutive capabilities of policymakers and researchers. This study seeks to empirically fill the gap and elucidate the magnitude of the relationship between ethnic background, travel behavior, and Covid-19 records to comprehend the motives behind the overrepresentation of ethnic minorities among Covid-19 infections and deaths rates in the Netherlands.

The literature review conducted in Chapter 2 analyzed the nature of ethnic inequality in the Netherlands from a socio-economic, demographic, health, and travel behavior standpoint. The intent of the literature review was: firstly, to understand the status quo of ethnic disparity in the Netherlands together with its contributing and constitutive factors; secondly, to identify the potential mediator variables between ethnic background and Covid-19 records. Finally, the literature review represents the backbone of this study, on which hypotheses are generated and the conceptual model designed (*Figure 5*).

As describes by its definition, a conceptual model is "a framework used in research to outline the possible courses of action or to present an idea or thought" (Elangovan & Raju, 2015), and it constitutes the underlying theory that supports any proposed hypothesis and justifies the causal relationships between variables. The variables included in this study are sorted into six different groups, namely ethnic background, socio-economic variables, demographic variables, health variables, travel behavior, and Covid-19 records. The first constitutes the ethnic composition of the Netherlands, divided into three general ethnic groups, from which only the non-western immigrant origins group is sub-divided into specific ethnic minorities for a reason reported in *Chapter 2.9.1*. The socio-economic, demographic, health, and travel behavior group are identified as mediator variables (*grey shaded*) aimed at explaining the relationship between ethnic background and Covid-19 infection and death rates. That is because ethnicity is not intrinsically related to a specific Covid-19 infection healthcare outcome, but precarious socio-economic, spatial, and health conditions, together with disadvantages in mobility opportunities during a health crisis, may have caused the higher incidence of infections and deaths among ethnic minorities.

Within the model, five 'general' relationships are identified and ordered in *Figure 5* with the letter *R*. Since studies have not found clear evidence for genetic or immune predisposition for Covid-19 by race or ethnicity (Carethers, 2020), the witnessed worrisome relationship between ethnic background and Covid-19 is not a direct relationship. However, the inclusion of a direct relationship between ethnic background and Covid-19 records (*R6*) will allow to capture what other relationships (*R1—R3—R5 or R2—R5*) might not be able to capture.

According to several studies (*Chapter 2*), the disproportionate incidence of Covid-19 infections on already disadvantaged ethnic minorities can be sourced to socio-economic, demographic, health, but also travel behavior disparity. Socio-economic, demographic, and health disparity has always been a social plague that caused disadvantages only for specific segments of the population (*R1*), and this definition has strengthened since the arrival of Covid-19 in everyone's daily life. In fact, studies have shown that low socio-economic groups and blu-collars, which are usually ethnic

minorities, are the ones that have suffered and lost the most during Covid-19, showing the strong relationship between socio-economic, demographic, and health disparities and Covid-19 records (*R4*). Studies have also shown that differences in mobility could have also played a role in this ethnic health crisis. Due to their socio-economic and spatial precariousness (*R3*), ethnic minorities are bound to use public transport and other 'unsafe' means of transport, which have been found to be a lifeline for previous and existing respiratory diseases to flourish. As a result, the disparity in travel behavior may represent a significant mediator between ethnic background and disproportionate Covid-19 infection and death rates (*R5*). As described in *Chapter 2.10.1.*, the relationship between ethnic background and travel behavior can be embodied by two forms of relationship. The first is how people's socio-economic, spatial, and health status affects personal travel behavior and accessibility to specific forms of transport (*R1—R3*). The second is the intrinsic cultural norms that prevent people from using specific means of transport, like a bike, and enhance other means of transport (*R2*).

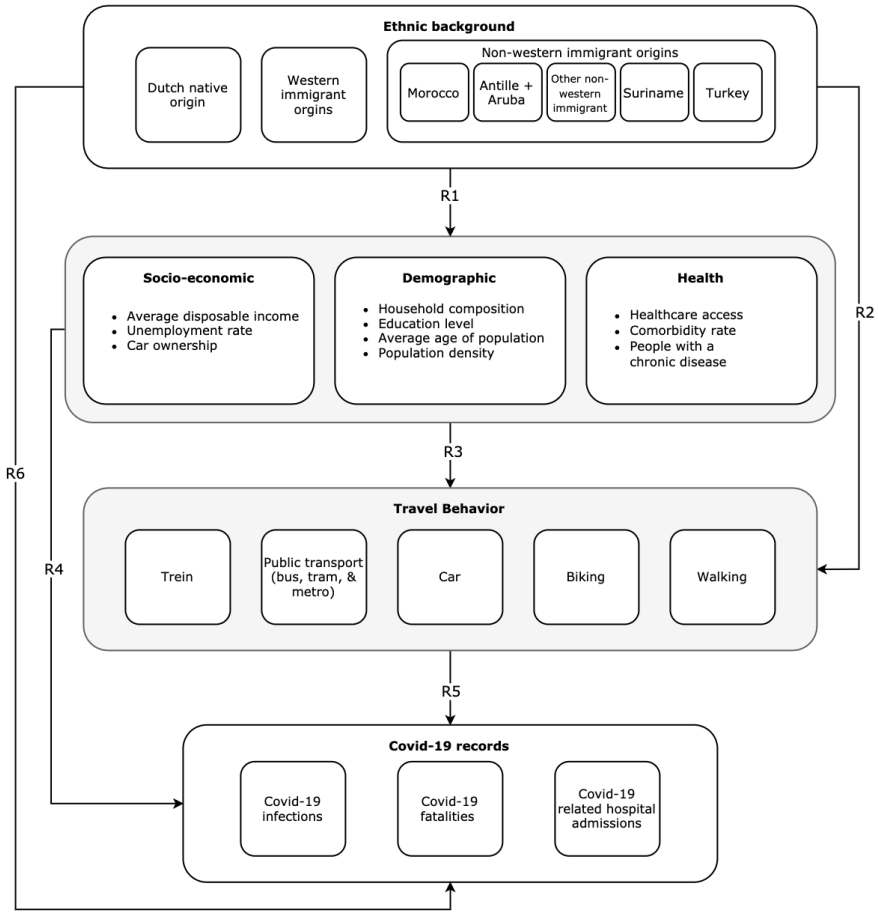



*Figure 5 - Conceptual model*

In conclusion, the conceptual model enables us to observe the potential ways in which ethnic background is related to Covid-19 records. Ethnicity is not directly related, but indirectly via socio-economic, demographic, and health conditions (*R1—R4*) or travel behavior (*R1—R3—R5 or R2—R5*). The direct link (*R6*) does not represent the direct relationship between ethnic background and Covid-19 records, but it stands as everything that the two indirect types of relationships can not

capture. In conclusion, this model enables us to assess the role of each mediating variable in this relationship and identify the relative impact of travel behavior on the relationship between ethnic background and Covid-19 records compared to other mediator variables (socio-economic, demographic, and health).

# 3. Methods and Data Specification

This chapter constitutes the pre-modeling process that describes the research methods, model specifications, and subsequent limitations. It will begin by describing the data that will be used for the modeling process. Secondly, this chapter will examine the list of variables offered by the data source and identify the variables of interest for this study. These variables will be selected and categorized following the form described in *Chapter 2.11. & 2.12*. Moreover, the key assumptions that have been made about the dataset and model specification will be given and discussed. In conclusion, this chapter will describe the modeling method specifications used in this study.

## 3.1 Data Source

The nature of this study permits to bring to the surface the causal relationship between ethnic background, travel behavior, and Covid-19 records in both aggregate and disaggregate manner. Researchers can either focus on elucidating the relative impact of travel behavior on the ethnic health disparity witnessed during Covid-19 in a disaggregated manner by studying the occurrence of this event in a specific municipality or by aggregately studying it by taking into account the Netherlands as a whole. However, as always, data represents a perennial limitation to every research's ambition. Disaggregate data is knowingly costly and challenging to obtain (Potoglou & Susilo, 2008a), and this difficulty intensifies when a recent and specific dataset is needed. Studying these relationships in a local context, such as a municipality, would require a disaggregated dataset that considers the ethnic, socio-economic, travel behavior, and Covid-19 rates differences between the composing neighborhoods, which is not yet available. On the other hand, the presence of aggregate data in the Netherlands is abundant and well-detailed. For the purpose of this study, which seeks to provide a comprehensive understanding of these relationships by taking into consideration the majority of Dutch's municipalities, the data will be fetched from Waarstaatjegemeente (VNG), a publicly available platform that bundles, processes, and presents data from and about municipalities for everyone (Waarstaatjegemeente, 2019). These 'dashboards' provides access to an extensive list of variables ranging from Covid-19 records, demographic, work & income to mobility for all the 353 Dutch municipalities in all important policy areas. It allows to compare variables between different municipalities, enabling to expose the underlying municipality-specific conditions that might be at the origin of the problem. The database comes from various sources such as municipalities, citizens and business polls, Statistics Netherlands, COELO, DUO, GGD, Kadaster, the Chamber of Commerce, the Electoral Council, NOC * NSF, Logius, RIVM, and veiligheid.nl; and its update frequency depends on the publication frequency for each data source, which can be either continuously, daily, or annually (Waarstaatjegemeente, 2019). Other specific datasets are available mobility and modal split in the Netherlands, such as the *Traffic Survey of The Netherland*s (Onderzoek Verplaatsingen in Nederland, OViN), or *Statistics Netherlands* (CBS), and the Knowledge Institute for Mobility Policy (Kennisinstituut voor Mobiliteitsbeleid, KiM).

## 3.2. Selection of Variables

The literature review conducted in *Chapter 2* identified six categories of variables that will be included in this study. The first one is named 'ethnic background' and refers to the ethnic composition of Dutch municipalities. It is followed by the 'socio-economic, demographic, and health' categories used to identify the underlying conditions of any socio-economic group. Then the 'travel behavior' category represents the mobility norms in the Netherlands, and it is composed of all the major mobility means. Lastly, the 'Covid-19 records' category refers to the measurable conditions on the impact of Covid-19 in the Netherlands. Each of these categories can not be simply measured by a single indicator; instead, it is composed of a large variety of indicators that seek to indicate the various shades of each category. For example, as described in Chapter *2.9.2.,* the socio-economy inequality in the Netherlands does not merely refer to differences in income but also to car ownership and employment. Both the literature review (*Chapter 2*) and the conceptual model (*Chapter 2.12*) represent the starting point for the variables selection process.

For each of the defined categories, the Waarstaatjegemeente platform offers a large variety of variables. The available variable's theme ranges from Covid-19 national rates, demographic, business and economy, work and income, education, health, mobility, and so on. These variables can be compared on different levels, from a municipal level to a regional or urbanism level, and temporally. Although the ample number of available variables offer the opportunity to conduct a detailed study, only variables that conform with the purpose of the study and that can offer valid inputs are taken into consideration. Each variable will be grouped into one of the six pre-defined categories, and its definition, latest dataset update, frequency, and source will be provided - as shown in *Table 6*.

*Chapter 2.9.1.* described the general ethnic composition of the Netherlands and analyzed how previous Dutch-based studies have included and segmented ethnic background. The ethnic composition dataset offered by CBS enables obtaining ethnic data in line with the ethic description of *Chapter 2.9.1*. Thus, the ethnic background category is divided into Dutch natives, western immigrants, and non-western immigrants, which is subdivided into its largest ethnic groups, namely Marocco, former Antilles & Aruba, Suriname, Turkey, and others.

Chapter 2 concluded with a series of hypothetical socio-economic, demographic, and health variables to be included in this study - as shown in table 5. These are the variables that could help to understand the socio-economic difference between ethnic groups and how that affected their differences in travel behavior and the overrepresentation of ethnic minorities among Covid-19 infections and deaths. The majority of the potential variables are available in the Waarstaatjegemeente platform, which collects socio-economic, demographic, and health data from several datasets described in Table 6. The only variable not available on a municipality level is car ownership, and thus will not be included. Table 6 provides a list of the variables included in this study, followed by their characteristics and description. It is important to mention that the year of the available dataset for all the variables is not the same. The majority of the datasets date back to 2019, however, some to 2020, 2018, and 2017. The motive behind this temporal irregularity between datasets is that some of the latest datasets have not yet been published and thus publicly available.

Several datasets offer an understanding of the Netherlands' mobility trends and travel modal split when it comes to mobility. *Waarstaatjegemeente* used three different dataset sources - Centraal

Bureau voor de Statistiek (CBS) - Onderzoek Verplaatsingen in Nederland (OViN) - Kennisinstituut voor Mobiliteitsbeleid (KiM) - to compare modal split between the main travel modes in the Netherlands. For this study, five main travel modes will be included: car, train, public transport (bus, tram, and metro), biking, and walking. These are also the travel modes that are impacted by the arrival of the Covid-19 pandemic. The latest publicly available dataset for mobility in the Netherlands is from 2017, and that's because some of the latest datasets, even if already collected, have not yet been published (Ministry of Infrastructure and Water Management).

The Covid-19 dataset obtained from the Dutch National Institute for Public Health and Environment (Rijksinstituut voor Volksgezondheid en Milieu RIVM) offers a detailed understanding of daily infection and death and hospitalizations related to Covid-19 in the Netherlands. All three variables will be included in the study to provide a broad understanding of how other variables relate not only to the infection rates but also to the death rates and hospital admissions.

*Table 6 - list, categorization, and description of included variables*

| Type of variable | Variable | Definition | Latest Update | Data update frequency | Source |
|---|---|---|---|---|---|
| Ethnic background | Dutch native origins | Number of people with a Dutch native background | 2020 | Annually | Centraal Bureau voor de Statistiek (CBS) Personen naar migratieachtergrond |
| | Western immigrant origins | Number of people with a first-generation or second-generation immigrant origin from central and eastern European countries, southern European countries, and by any other western countries (United States, Australia, Japan, Indonesia etc.). | 2020 | Annually | Centraal Bureau voor de Statistiek (CBS) Personen naar migratieachtergrond |
| | Morocco (non-western immigrant origins) | Number of people with a first-generation or second-generation immigrant origin from Morocco | 2020 | Annually | Centraal Bureau voor de Statistiek (CBS) Personen naar migratieachtergrond |
| | Former Antilles & Aruba (non-western immigrant origins) | Number of people with a first-generation or second-generation immigrant origin from the former Netherlands Antilles and Aruba | 2020 | Annually | Centraal Bureau voor de Statistiek (CBS) Personen naar migratieachtergrond |
| | Suriname (non-western immigrant origins) | Number of people with a first-generation or second-generation immigrant origin from Suriname | 2020 | Annually | Centraal Bureau voor de Statistiek (CBS) Personen naar migratieachtergrond |
| | Turkey (non-western immigrant origins) | Number of people with a first-generation or second-generation immigrant origin from Turkey | 2020 | Annually | Centraal Bureau voor de Statistiek (CBS) Personen naar migratieachtergrond |

| | | | | | |
|---|---|---|---|---|---|
| | Other non-western immigrant origins | Number of people with a first-generation or second-generation immigrant origin from other non-western countries (Asia, Africa, and South America) | 2020 | Annually | Centraal Bureau voor de Statistiek (CBS) Personen naar migratieachtergrond |
| Socio-economic | Unemployed rate | Share of the unemployed labor force as percentage of the total (employed and not-employed) population between 15 and 17 years old | 2019 | Annually | Centraal Bureau voor de Statistiek (CBS) Arbeidsdeelname naar regio |
| | Workforce with a low education | Number of workers with a low education level | 2019 | Annually | Centraal Bureau voor de Statistiek (CBS) Arbeidsdeelname naar regio |
| | Workforce with a secondary level education | Number of workers a secondary education level - preparatory vocational secondary education (vmbo), senior general secondary education (havo), and university preparatory education (vwo) | 2019 | Annually | Centraal Bureau voor de Statistiek (CBS) Arbeidsdeelname naar regio |
| | Workforce with a high education | Number of workers with a HBO (university of applied sciences) and WO (academic university education) diploma | 2019 | Annually | Centraal Bureau voor de Statistiek (CBS) Arbeidsdeelname naar regio |
| | Household disposable income | Average households's disposable income (it includes all private households with a known income - not excluding student households) | 2018 | Annually | Centraal Bureau voor de Statistiek (CBS) Integraal Inkomens- en Vermogensonderzoek |
| Demographic | Population age | Average age of Netherlands residents | 2020 | Annually | Centraal Bureau voor de Statistiek (CBS) Bevolkingsstatistiek |
| | Population density | Average number of inhabitants per km² | 2020 | Annually | Centraal Bureau voor de Statistiek (CBS) Bevolkingsstatistiek |
| | Persons per household | Average number of people per household | 2020 | Annually | Centraal Bureau voor de Statistiek (CBS) Huishoudensstatistiek |
| | Healthcare users | Percentage of insured persons using primary care - general practitioners (GPs) | 2019 | Annually | Vektis - Zorggebruikers |
| | Comorbidities rate | Percentage of policyholders with two or more chronic conditions from a list of a total of thirty chronic conditions such as diabetes, chronic obstructive pulmonary disease (COPD), cardiovascular disease, rheumatism, and cancer. | 2019 | Annually | Vektis - Zorggebruikers |

| | | | | | |
|---|---|---|---|---|---|
| Health | Chronic obstructive pulmonary disease (COPD) and Asthma | Number of people suffering of chronic obstructive pulmonary disease (COPD) and asthma | 2017 | Annually | Vektis - Zorggebruikers |
| | Heart failure | Number of people suffering of heart failure | 2017 | Annually | Vektis - Zorggebruikers |
| | Diabetes | Number of people suffering of diabetes | 2017 | Annually | Vektis - Zorggebruikers |
| | Rheumatism | Number fo people suffering of rheumatism | 2017 | Annually | Vektis - Zorggebruikers |
| | Cancer | Number of people suffering of cancer | 2017 | Annually | Vektis - Zorggebruikers |
| Travel Behavior | Car | The share of trips made with a car as a driver | 2017 | Annually | Centraal Bureau voor de Statistiek (CBS) - Onderzoek Verplaatsingen in Nederland (OViN) - Kennisinstituut voor Mobiliteitsbeleid (KiM) |
| | Train | The share of trips made with a train | 2017 | Annually | Centraal Bureau voor de Statistiek (CBS) - Onderzoek Verplaatsingen in Nederland (OViN) - Kennisinstituut voor Mobiliteitsbeleid (KiM) |
| | Public transport | The share of trips made with public transport, which consists in bus, tram, and metro | 2017 | Annually | Centraal Bureau voor de Statistiek (CBS) - Onderzoek Verplaatsingen in Nederland (OViN) - Kennisinstituut voor Mobiliteitsbeleid (KiM) |
| | Biking | The share of trips made with a bike | 2017 | Annually | Centraal Bureau voor de Statistiek (CBS) - Onderzoek Verplaatsingen in Nederland (OViN) - Kennisinstituut voor Mobiliteitsbeleid (KiM) |
| | Walking | The share of trips made by walking | 2017 | Annually | Centraal Bureau voor de Statistiek (CBS) - Onderzoek Verplaatsingen in Nederland (OViN) - Kennisinstituut voor Mobiliteitsbeleid (KiM) |

| | | | | | |
|---|---|---|---|---|---|
| Covid-19 Records | Infections | Total number of people per 100,000 inhabitants who have tested positive for Covid-19 | From 13/03/2020 till 22/04/2021 | Daily | Rijksinstituut voor Volksgezondheid en Milieu (RIVM) |
| | Hospital admission | Total number of confirmed positive Covid-19 cases that have been admitted to the hospital per 100,000 inhabitants | From 13/03/2020 till 22/04/2021 | Daily | Rijksinstituut voor Volksgezondheid en Milieu (RIVM) |
| | Deaths | Total number of people per 100,000 inhabitants who have died as a result of Covid-19 | From 13/03/2020 till 22/04/2021 | Daily | Rijksinstituut voor Volksgezondheid en Milieu (RIVM) |

## 3.3. Data and Measures - Descriptive Statistics

Each of the observed variables described in *Table 6 is* measured by considering 352 Dutch municipalities, which represents the entire Dutch population. Due to the magnitude of this data, this study will not analyze a sample but the whole population; therefore, a test to investigate whether the data is representative of the population is unnecessary. For some municipalities, such as Eemsdelta, the data is not complete, and there are missing values. All the missing values are derived from the 'household disposable income' variable. A total of 7 values within the 'household disposable income' are missing, representing 1.99% of the total number of values per variable (N=352). No other variable has missing values. To handle the missing values in the model, the Full Information Maximum Likelihood (FIML) estimator - a missing data handling technique for estimating interaction effects in multiple regressions (Cham et al., 2016) - was used to impute the probable values for the missing data based on the model's structure. This method has been shown to yield unbiased estimates and be more efficient than other methods (Enders & Bandalos, 2001). The original datasets for most variables, excluding healthcare users, comorbidities rate, and the travel behavior variables, were composed of absolute values which are hard to interpret. Each variable's dataset has been converted to represent a portion of the municipality's total population and to ensure interpretability. *Table 7* represents the descriptive statistics of this study's dataset. Descriptive statistics are conventionally used to describe a dataset's features in a study, providing key pieces of information about it. For this study, the descriptive statistics comprises three categories, namely frequency distributions (count of datapoint per variable (N)), central tendency (mean), and measures of variability (standard deviation, range, minimum and maximum data points).

*Table 7 - Descriptive statistics*

| Type of variable | Variable | Mean | Std. Deviation | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| Ethnic background | Dutch native origins | 83.51% | 8.89% | 44.42% | 95.84% | 51.43% |
| | Western immigrant origins | 8.79% | 4.46% | 1.64% | 46.82% | 45.18% |
| | Morocco (non-western immigrant origins) | 1.08% | 1.49% | 0.00% | 9.56% | 9.56% |
| | Former Antilles & Aruba (non-western immigrant origins) | 0.58% | 0.57% | 0.02% | 4.05% | 4.03% |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Suriname (non-western immigrant origins) | 0.87% | 1.37% | 0.00% | 11.53% | 11.53% |
| | Turkey (non-western immigrant origins) | 1.23% | 1.63% | 0.00% | 10.15% | 10.15% |
| | Other non-western immigrant origins | 4.01% | 2.34% | 1.21% | 18.85% | 17.64% |
| Socio-economic | Unemployment rate | 2.93% | 0.55% | 2.20% | 5.90% | 3.70% |
| | Workforce with a low education | 11.59% | 2.61% | 0.00% | 20.46% | 20.46% |
| | Workforce with a secondary level education | 22.41% | 3.56% | 0.00% | 30.51% | 30.51% |
| | Workforce with a high education | 17.91% | 4.81% | 0.00% | 39.71% | 39.71% |
| | Household disposable income | 45228.41 | 5543.26 | 33700 | 78000 | 44300 |
| Demographic | Population age | 43.48 | 2.33 | 32.2 | 49.9 | 17.7 |
| | Population density | 887.86 | 1054.62 | 23 | 6620 | 6597 |
| | Persons per household | 2.29 | 0.18 | 1.71 | 3.31 | 1.60 |
| Health | Healthcare users | 82.33% | 11.11% | 24.30% | 99.10% | 74.80% |
| | Comorbidities rate | 4.21% | 0.73% | 1.40% | 7.10% | 5.70% |
| | Chronic obstructive pulmonary disease (COPD) and Asthma | 4.25% | 0.65% | 2.33% | 6.15% | 3.82% |
| | Heart failure | 3.59% | 0.64% | 2.00% | 6.20% | 4.20% |
| | Diabetes | 2.28% | 0.52% | 1.14% | 4.22% | 3.08% |
| | Rheumatism | 1.98% | 0.33% | 1.14% | 3.09% | 1.96% |
| | Cancer | 3.43% | 0.62% | 1.53% | 6.39% | 4.86% |
| Travel Behavior | Car | 35.23% | 5.24% | 5.20% | 46.40% | 41.20% |
| | Train | 1.46% | 1.18% | 0.00% | 7.40% | 7.40% |
| | Public transport | 1.38% | 1.49% | 0.00% | 11.10% | 11.10% |
| | Biking | 27.18% | 6.03% | 8.10% | 54.40% | 46.30% |
| | Walking | 16.99% | 3.24% | 9.40% | 35.40% | 26.00% |
| Covid-19 Records | Infections | 8.16% | 1.93% | 0.00% | 17.94% | 17.94% |
| | Hospital admission | 0.15% | 0.06% | 0.00% | 0.37% | 0.37% |
| | Deaths | 0.09% | 0.05% | 0.00% | 0.25% | 0.25% |

As previously described, this comprehensive study includes all the 352 Dutch municipalities. Thus, every variable has a datapoint per municipality. The ethnic composition of Dutch's municipality is generally dominated by the Dutch native segment of the population, representing on average 83.5% of the municipality's population. However, it is important to mention that the share of Dutch natives diminishes as the size of the municipality population increases.In fact, municipalities such as Amsterdam and Rotterdam register some of the lowest numbers of Dutch native's population (44.4%), underlining the prevalence of non-Dutch ethnic groups in major Dutch cities. The presence of ethnic minorities varies by the urban levels. Generally, smaller cities are majority populated by Dutch natives, while the share of people with an immigrant origin climbs as an urban area increases in the number of inhabitants. The "Western immigrant origins" ethnic group is tendentially the biggest among the ethnic minorities in Dutch municipalities with a mean of 8.8%, followed by "other non-western immigrant origins" (4.01%) and "Turkey" (1.23%). The "Former Antilles & Aruba" and "Suriname" ethnic groups represent the smallest ethnic minorities in the Netherlands with respectively a mean of 0.58% and 0.87% of a municipality population. Once again, generally, the share of these ethnic minorities fluctuates depending on a municipality's size and population density.

The mean unemployment rate in the country is set just below the 3% mark; however, it increases in highly populated urban areas, such as Rotterdam (5.9%) or Den Haag (5.1%). Large cities also perish from a lower household's disposable income (Amsterdam (40,300) or Rotterdam (36,700)) compared to their rural counterparts. The population's education level also is deeply intertwined with the size and demographic of a municipality. Although on a national level the workforce with a secondary level education represents a slight majority, the degree of education level increases in urban areas and in student towns such as Groningen, where 27.9% of the workforce is highly educated compared to only 7.3% of the workforce with a low education level. Lower to medium level of education is dominant in rural areas where agricultural and manufacturing jobs predominate. The national household composition (number of people in a household) is 2.29 with a small standard deviation, meaning that each municipality's value tends to be close to the mean. However, it is important to mention that the number of people in a household decreases as the municipality's size increases due to the higher presence of single households.

On average, in the Netherlands, 82.3% of a municipality's population utilizes primary care, except for few municipalities that register a much smaller number of primary care users (24.3%). Among policyholders, a mean of 4.21% suffers from comorbidity, including chronic diseases like obstructive pulmonary disease (COPD), asthma, heart failure, diabetes, rheumatism, and cancer. The small standard deviation demonstrates that there is low dispersion for comorbidities rates among Dutch municipalities, and it is similar across them with few outliners.

The modal split among 352 Dutch municipalities sees car mobility as the nationwide leading mean of transport, with an average of 35.2% of municipalities population opting to drive for their daily activities. Biking and walking are the second and third most used means of transport, something unique to Dutch mobility culture facilitated by the extensive bike infrastructures. Public transport (PT) and train modal share remains low nationally with a mean respectively of 1.38% and 1.46%, with a considerable standard deviation, going to indicate that several municipalities have a high share of PT and train users - this is true for major cities, such as Amsterdam or Rotterdam, with vast and accessible public transport options.

The Covid-19 related dataset obtained from the Rijksinstituut voor Volksgezondheid en Milieu (RIVM) initially indicated the number of infected, deaths, and hospital admission per 100,000

inhabitants for each municipality on any specific date. This dataset has been aggregated considering the total number of infected, deaths, and hospital admissions from 13/03/2020 till 22/04/2021. Instead of representing the Total number of people per 100,000 inhabitants, it has been adapted to show the total number of infections, deaths, and hospital admission in relation to each municipality's total number of inhabitants. The descriptive statistics show that, on average, 8.16% of each municipality's population got infected by Covid-19 since the pandemic's beginning (13/03/2020), with several municipalities registering up to 17.9%. The dataset shows that several municipalities have disproportionally suffered more than others; however, it is yet not clear the reason behind this incidence.

## 3.4. Data Assumptions and Limitations

Even though *Waarstaatjegemeente* offers unique and simplified access to a large variety of comprehensive datasets with a large number of variables that cover most of the Dutch municipalities, several limitations are resulting from the nature of the datasets and the assumptions that are at the basis of this study that needs to be taken into account ahead of the modeling section.

Firstly, the year of publication of each used dataset varies dependently on the genre of each dataset. The majority of the ethnic-related and demographic variables have been gathered from datasets dating back to 2019 and 2020. The recency of the available dataset improves in the case of Covid-19 related datasets, obtained from Rijksinstituut voor Volksgezondheid en Milieu (RIVM), which publishes the daily count of Covid-19 infections, deaths, and hospital admission for all Dutch municipalities. In the case of health and travel behavior variables, the latest available dataset is 2017, with some exceptions in the health domain, which fails to provide a recent view on Dutch travel behavior and health conditions. The remoteness of the health dataset hides the actual health conditions, such as the percentage of healthcare users and comorbidities rates, of the Netherlands's inhabitants during Covid-19. Having access to a recent health dataset during a health crisis can be beneficial in assessing potential health disparities and understanding potential underlying key drivers behind the disproportionate impact of Covid-19 on ethnic minorities. However, the lack of up-to-date data for the travel modal split in the Netherlands during the Covid-19 pandemic represents a significant limitation for this study, and it subsequently requires the establishment of consequential assumptions. The 2017's modal split dataset hinders the faculty of analyzing travel behavior changes during a health crisis, which is known to undergo alteration because of the socio-economic implications of such calamities; instead, it only offers travel data on the most used means of transport for a period free of any major externality. Subsequently, this study is founded on the assumption that the modal split remains unaltered during the Covid-19 pandemic retaining the 2017 levels. The impact's magnitude on each means of mobility varies depending on the location of a study, on the typology of the used dataset, and on the period of reference (the health implications of a pandemic vary temporally depending on the interventions stringency and social behavior). In contrast, some geographically comprehensive studies - based on public datasets like the Apple mobility trends report - record a common and similar negative impact of the pandemic on the various mobility modes (Medimorec et al., 2020); others that are based on a contained online questionnaire survey, identify public transport (bus, train, tram, and metro) as the major victim for the benefit of private means of transport such as car raiding or biking (Abdullah et al., 2020). In the case of the Netherlands, public transport has disproportionally suffered more than car driving or biking (Apple Mobility Trends Reports, 2020). However, compared to pre-Covid-19 levels, the modal split between these three mentioned means of transport remains approximately unchanged, with walking and driving holding a strong share and

public transport the opposite (note: look at *Chapter 3.3* for the pre-Covid travel modal split). This being said, this assumption, despite its obvious limitations, can offer an insightful understanding of the role of mobility in the relationship between ethnic background and Covid-19 infection/deaths rates.

Secondly, measuring the socio-economic and health conditions of a municipality's ethnic groups is far from straightforward. Socio-economic status does not depend solely on the level of education, disposable income, and unemployment rate, but it depends on a wider and detailed range of institutional, cultural, and social factors. This study attempts to outline a general idea of the socio-economic and health characteristics based on the availability and reliability of the accessible variables and datasets. Thus, in order to ensure parsimony in the analysis, which is usually a favorable procedure if backed up by rationality (Sivo & Willson, 1998), only key variables that have been identified by literature as subject to changes as a consequence of Covid-19 and on which public aggregate datasets are available have been included in the study. This line of thinking has also been applied for the selection of travel behavior-related variables. Although mobility is multifaceted and varies between public, shared, and private mobility, only the five most common means of transport have been selected for this study. Obscuring the impact of many other variables in this study represents a limitation; however, it can also benefit the result's reliability and comprehension.

Thirdly, this study is made possible by using several different datasets publicized and retrieved from different entities. Although it enables a comprehensive analysis of each municipality's socio-economic, demographic, health, travel, and Covid-19 records characteristics, it also represents a limitation by itself. It is not clear how the data collection process varies among each fount, and it is not easy to certify the quality and reliability of each process.

## 3.5 Methodology

The study will use a quantitative research approach to outline a response to the main question. Quantitative research is a statistical approach used for testing objective theories by examining the relationship by a set of variables (Creswell, 2014), where data is used to measure reality (Williams, 2007). This strategy involves complex experiments with many variables and treatments to describe and measure their degree of association (Creswell, 2012). Quantitative researchers focus on objectivity and emphasize measuring variables and testing hypotheses associated with a general causal explanation (Neuman, 2006). There are several advantages associated with this method. As Choy (2014) explains, numerical data facilitates the comparison between groups and the explanation of the relationship between variables, and it allows the determination of the extent of those relationships. This type of research allows to understand the context of problems (Almeida, 2017), even on a national scale, and enables straightforward analysis.

The quantitative research technique in question is Structural Equation Modelling (SEM). SEM is a widely known technique used to create and test models that "hypothesize how sets of variables define constructs and how these constructs are related to each other" (Schumacker & Lomax, 2010). Each model is founded on theory and empirical evidence retrieved from literature, and the end goal of an SEM construct is to define well a theoretical model is validated by sample data (Schumacker & Lomax, 2010). By means of the sample data, the model can be deemed accurate or considered inefficient. The role of the researcher is to develop, analyze, and modify a theoretical model while maintaining theoretical soundness.

The structural model is a graphical exhibition of the relationships established through assumptions regarding the direction of the relationship among variables. This graphical representation is called a path model, which is a generalization of multiple regressions. It allows explaining the observed correlations by direct, indirect, and spurious effects. This construct is composed of a set of building blocks that can be sorted into three categories:

- Variables: A variable is a factor that can be either observed (measurable variables) or unobserved (latent). Latent variables are not directly measured and are intrinsically linked to the essence of the indicators variables used to define and measure them

- Relationships: A relationship between two variables can be either direct or indirect. Direct relationships are represented by a causal path, where causality is assumed, or by correlations, where there is an association but not causality assumed. Indirect relationships between two variables pass through the relationship, by means of casual paths or correlations, between multiple variables.

- Parameters: Parameters are either fixed or free

SEM is composed of the measurement model and the structural model. "A measurement model measures the latent variables or composite variables, while the structural model tests all the hypothetical dependencies based on path analysis" (Fan et al., 2016). A full model - containing both measurement and structural models - is known as a SEM model with latent variables, which is not always used in practice (Golob, 2001). Researchers can opt to design a distinct variety of path models that differ in structure and theory; some of these models can either full models, ones without any measurement model, or measurement models only where latent variables are excluded, and only observable variables are studied (Golob, 2001). Observed variables can either be exogenous or endogenous. Exogenous variables, also identified as cause variables, are independent of any other variable and are depicted without any incoming arrow. On the other hand, endogenous variables, also known as effect variables, are dependent on exogenous variables and have at least one incoming arrow, and are bound up with an error term representing the unexplained variance of the endogenous variables.

Path models are conducted using SPSS AMOS graphics, a leading software in the field of structural equation modeling (SEM). As mentioned, drafting the path diagram is preceded by the model specification, where all of the available relevant literature, theory, and information is gathered and analyzed to develop a theoretical model (Schumacker & Lomax, 2010). This task involves indenting every variable, parameter, and relationship that is of interest to the researcher to model based on theoretical soundness. The following step is model identification to check if the model is over-identified, just-identified, or under-identified. Subsequently, the model is evaluated by checking its performance through quantitative indices calculated for the overall goodness of fit (Fan et al., 2016). *Table 8* illustrates a summary of the model fit criterion together with the acceptable level and interpretation.

*Table 8 - Model-Fit Criteria and Acceptable Fit Interpretation*

| Model Fit Criterion | Acceptable Level | Interpretation |
|---|---|---|
| Chi-square | Tabled $\chi^2$ value | Compares obtained $\chi^2$ value with tabled value for given *df* |
| Goodness-of-fit index (GFI) | 0 (no fit) to 1 (perfect fit) | Value close to .90 or .95 reflect a good fit |
| Adjusted GFI (AGFI) | 0 (no fit) to 1 (perfect fit) | Value adjusted for *df*, with .90 or .95 a good model fit |
| Root-mean square residual (RMR) | Researcher defines level < .05 | Indicates the closeness of **Σ** to *S* matrices |
| Standardized RMR (SRMR) | < .05 | Value less than .05 indicates a good model fit |
| Root-mean-square error of approximation (RMSEA) | .05 to .08 | Value of .05 to .08 indicate close fit |
| Tucker–Lewis Index (TLI) | 0 (no fit) to 1 (perfect fit) | Value close to .90 or .95 reflects a good model fit |
| Normed fit index (NFI) | 0 (no fit) to 1 (perfect fit) | Value close to .90 or .95 reflects a good model fit |
| Comparative fit index (CFI) | 0 (no fit) to 1 (perfect fit) | Value close to .90 or .95 reflects a good model fit |
| Parsimony fit index (PNFI) | 0 (no fit) to 1 (perfect fit) | Compares values in alternative models |
| Akaike information criterion (AIC) | 0 (perfect fit) to positive value (poor fit) | Compares values in alternative models |

Source: "A Beginner's Guide to Structural Equation Modeling", Schumacker & Lomax (2010)

All the model-fit criteria described in *Table 8* serve a common purpose: to assess the reliability and performance of a model. According to Hopper et all. (2007), among dozens of model-fit criteria offered by AMOS, a minimum of the following indices should be considered: The model Chi-square, RMSEA, CFI, and PNFI. Among these, the RMSEA and CFI are the most commonly used, and both are obtained using the SEM chi-square model fit statistic ($\chi 2M$ ) and *df* (*df M* ) (Peugh & Feldon, 2020). The fit of the model does not depend only on the quality of the path diagram constructed. However, it is also known to be influenced by sample size (Marsh et al., 2004), the number of variables analyzed, and model complexity - in general, model fit worsen as the number of variables in the model increases - (Kenny and McCoach, 2003), and missing data (Savalei, 2011). These limiting points will be thoroughly discussed in reflection with the developed model for this study.

Structural equation modeling (SEM) represents a unique alternative to conventional multivariate procedures. According to Malkanthie (2015), SEM offers the following advantages:

- SEM can estimate error variance parameters, unlike traditional multivariate procedures that are unable to do it
- SEM allows to include latent variables, while traditional multivariate procedures observed measurements only

- SEM assists researchers to modify a model and improve its fit by means of modification indices

- SEM allows for both a confirmatory and exploratory approach to the data analysis

Structural equation modeling (SEM) is used in a wide range of fields and applications, especially in the behavioral and psychology domain; however, it is also deemed as a key tool in travel behavior studies. One of the earliest applications of this method to travel behavior dates back to 1981 where Lyon (1981b) studied a dynamic model of mode choice and attitudes. With years the advantages of this tool quickly evolved, allowing for deepening studies on travel demand modeling using cross-sectional data (Axhausen, 2001; Golob, 1988), dynamic travel demand modeling (Van Wissen & Golob, 1992), and attitudes, perceptions, and hypothetical travel choices (Golob and Hensher, 1998; Levine et al.,1999).

It is important to clarify that, just like other statistical tools, SEM requires the achievement of the underlying assumptions in order to ensure accurate deductions. One critical assumption that is worth mentioning is "Normality". Normality is perhaps the most important assumption that needs satisfied before developing and interpreting a model. Normality refers to the fact that all the observations must draw draw from a continuous and multivariate normal population (Kumar, 2015). However, this is not always respected in practice, and this study represents one of these occasions. The effects of non-normality of a SEM study results a widely known, with existing literature affirming that non-normality does not affect parameter estimates; however, in regards to the goodness of fit, researches indicate that it can lead to significant overestimation of the likelihood ratio chi-square statistics related to the number of the df of the model (Kaplan, 2001).

# 4. Model Specifications and Results

This chapter discusses the results obtained from the developed models. It begins by elaborating on the model specification of the three model's versions. The first two versions for this purpose, named model 1a and model 1b, will consider the municipalities' subdivision between Dutch natives and people with an immigrant background. The latter, named model 2, will break down the immigrant-origin category with the most prominent ethnic minority groups that form is described in *Chapter 2.9.1,* focusing on their theoretical and structural characteristics. Subsequently, for each model, the results will be illustrated, interpreted, and discussed with the intent of presenting a conclusion to the posed main question. Each model's result will be discussed in the following manner: firstly, the relationship between ethnicity and socio-economic, spatial, health, and travel behavior variables will be interpreted and compared to what is found in the literature; secondly, the relationship between travel behavior (TB) and Covid-19 will be interpreted and compared to the strength of the relationship between socio-economic, spatial, and health variables with Covid-19 records; lastly, the relationship between ethnic background and Covid-19 records with socio-economic, spatial, health, and TB variables acting as mediators will be analyzed. Final remarks and concluding interpretations will be erected based on the facts of the results. A brief summary will be included after each result's section to improve reading convenience for the reader.

## 4.1. Models Specifications

For this study, models 1a, 1b, and 2 are developed as structural models - where every considered variable is observed, and latent variables are omitted - testing all the hypothetical dependencies based on path analysis (Fan et al., 2016). All three models are constituted by a structural model, or path model, which consists of exogenous (independent) and endogenous (dependent) variables depicted by a square and connected by arrows (indicating causal relationships) that go from the former to the latter. The model's structure and relationships have been introduced in *Chapter 2.12*. and illustrated by the conceptual model depicted in *Figure 5,* which has functioned as the foundation for this study's modeling process. Initially, the models were conceived as full models, containing both a structural and a measurement model, with a latent variable indicating the Covid-19 implications that affected Dutch municipalities. The 'Covid-19' latent variables had three indicators (covid-19 infections, hospital admissions, and deaths) meant to represent the "effects" of the pandemic. An illustration of this conceptual model is depicted in *Figure 13 (Appendix)*. Although the path loading of all three indicators was strong and the model yielded interesting results, similar to the structural models used in this study, the full models did not have a good fit, and thus they were discarded. The 'Covid-19' latent variable was replaced by the observed endogenous variables of the three Covid-19 implications (infections, hospital admission, and deaths), making the models structural.

### 4.1.1. Model 1a and 1b Specifications

While the conceptual model (*Figure 5*) includes the various facets of the Netherlands demographic, both models 1a and 1b aim to analyze the situation considering the mere split between Dutch natives and people with immigrant origins. However, since both ethnic variables are complementary, only one is included in each model; including both in one unique model would result in strong multicollinearity between the two ethnic variables, imperiling the results' quality. Thus, model 1a considers the set of ethnic minorities living in the Netherlands identified as 'immigrant origins', while model 1b replaces it with the ethnic group 'Dutch natives', which consists of the most populous ethnic group in the Netherlands. Model's 1a complete structure is depicted in *Figure 7* - a clearer and informative version is offered by *Figure 6* - while model 1b is depicted by *figure 11* (located in the *appendix*). For the sake of clarity, only model 1a is elaborated and discussed in this chapter because both models are complementary, and discussing both would become redundant.

The relationships in model 1a and model 1b are derived from the conceptual model (*Figure 5*) and are depicted in *Figure 6* using the same appellative (R). Within the model, only the 'immigrant origins' variables are exogenous and thus independent. Conceptually, it is indicated as independent because ethnicity is not influenced by other mentioned variables (e.g., travel behavior); however, the opposite effect is true: ethnicity is a major predictor of socio-economic, spatial, health, and travel behavior conditions (U.S. Census Bureau, 2009). Every other variable in the model is dependent and influenced by either exogenous or endogenous variables. In the graphical representation of model 1a *(Figure 6*), endogenous variables are distinguished from exogenous variables by two characteristics: incoming arrows and error terms. The unidimensional arrows flowing from exogenous variables to endogenous variables represent the causal relationship that is presumed to exist among variables in the system (Karadağ, 2012) and are labeled by 'R'. Each illustrated relationship (R1 to R5) is thoroughly described in *Chapter 2.12*. and does not conceptually vary from model 1a/b to model 2. The error term represents the unexplained variance of the endogenous variables to which it is connected - the cause variables do not explain the residual variance. Each error term is connected to its endogenous variables by an outgoing path error, which - during the modeling process - is by default fixed to 1.

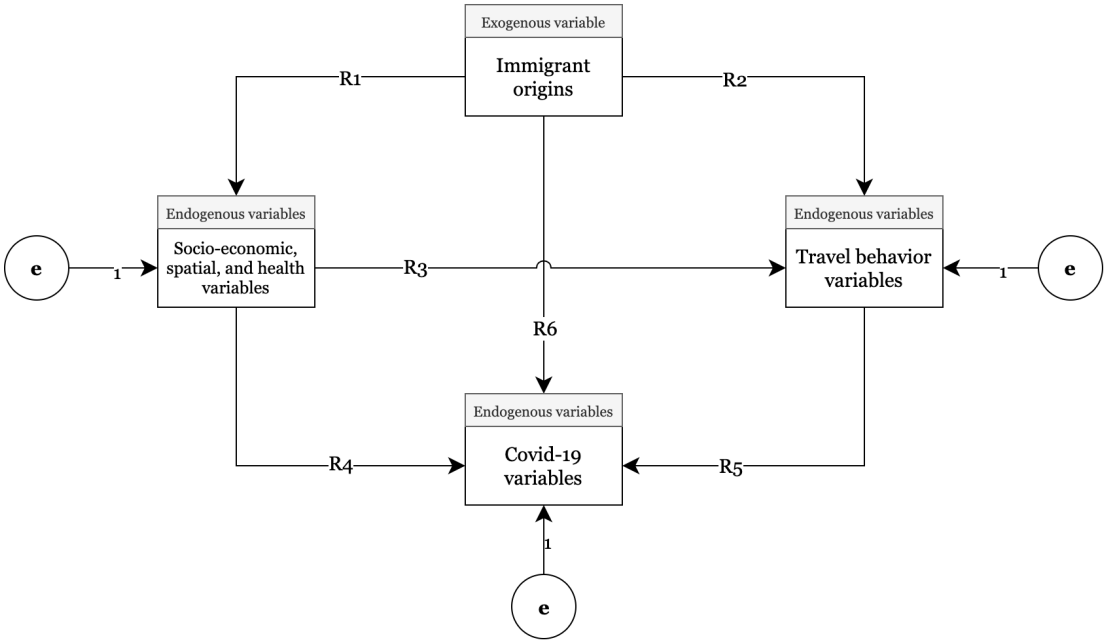



*Figure 6 - Simplified version of Model 1a specifications*

As depicted in *Figure 7*, clusters of error terms appertaining to one of the four variables' categories are correlated by bidirectional arrows that run from one variable to the other. Correlating error terms is a common practice in Structural Equation Modeling designed to represent the potential influence that these variables can have on each other and their mutual correlation because they might have some common cofounding variables, but they are correlated. It is important to take the correlation into account to acquire the unique effects of these variables on later variables in the causal chain. This overlap between variables is not explicitly modeled - as it does not represent the focal point of this study - however, it is englobed in the study through the correlation among error terms. Allowing correlated error terms is a matter of controversy in the field of behavioral modeling. Few authors have cautioned against this practice, claiming that it might be merely used to enhance model fit, disregarding any theoretical soundness (Hermida, 2015; Anderson & Gerbing, 1984; Landis et al., 2009). Others have advocated for this practice, pointing out that wasting data because of a miss-fitting model, as a result of also omitting correlations between error terms, might turn out more disadvantageous than including error terms correlations to improve the model's fit (Hermida et al., 2010; Sörbom, 1989). In conclusion, this study opts to include the mentioned corrections between error terms of the same category to consider any relationship between the same categories variables that might impact later variables in the causal chain. For example, while studies have shown that family income significantly influences children's education level (Lv, 2017), this study does not directly consider this causal effect since a unidirectional arrow does not directly relate to both variables. However, allowing correlated error terms between these variables ( e2 <-> e3, e2 <-> e4, or e2 <-> e5) from the same category allows to take into consideration their correlation and contributes to the identification of the unique effect of 'household disposable income' on later variables on the causal chain like any of the travel behavior variable (e.g. 'public transport').

Figure 7 illustrates the full path model 1a, including every considered variable, causal path, error term, correlation, and categorization of variables. The relationships between variables (endogenous and exogenous) are simplified by one demonstrative arrow, which symbolizes the relationship between every source variable to every destination variable, to ensure that the model representation is readable and clear

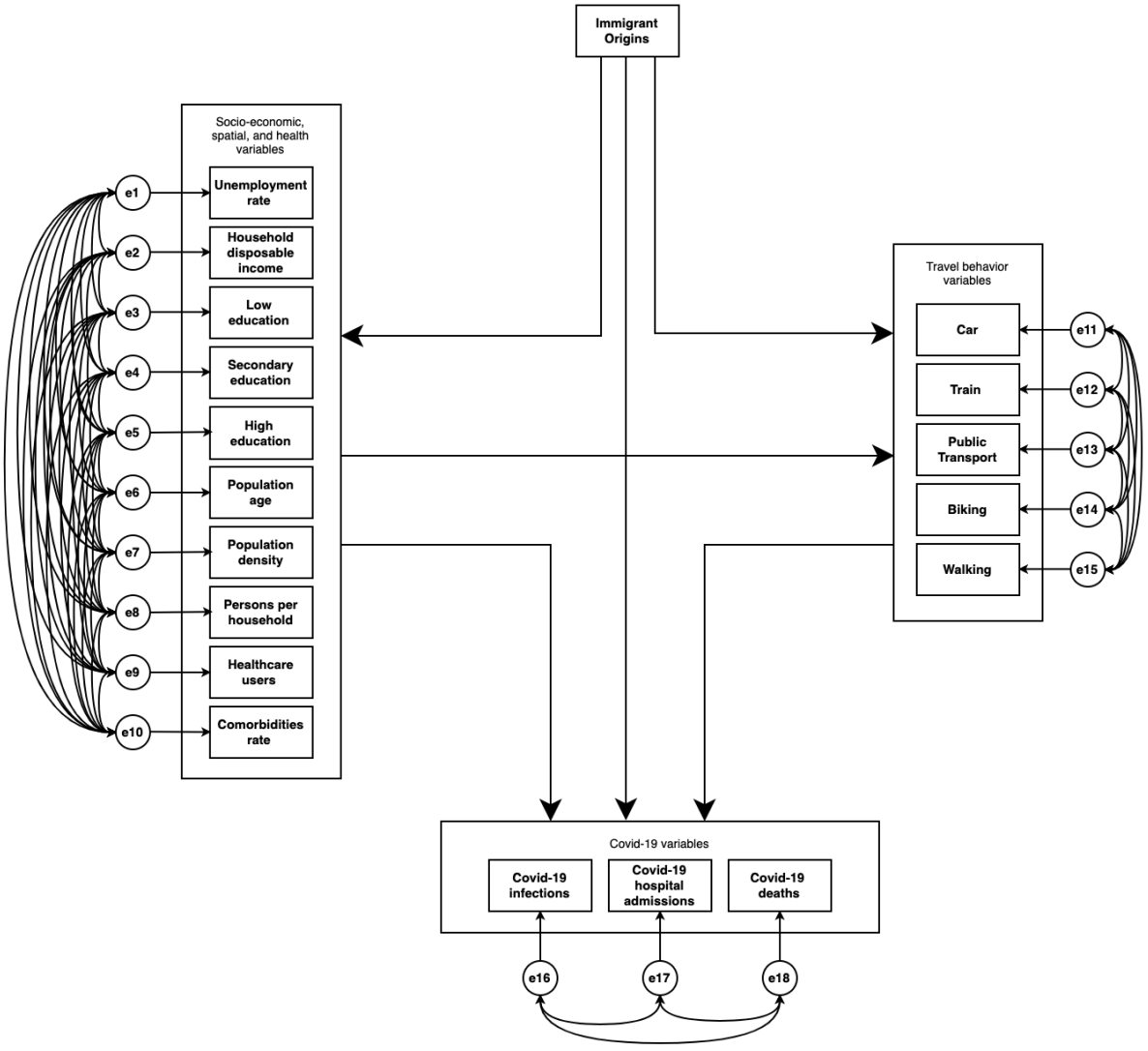



Figure 7 - Model 1a specification - Structural Equation Modeling

### 4.1.2. Model 2 Specifications

Model 2 is an ethnic-related in-depth version of model 1a/b that seeks to break down the umbrella category of people with immigrant-origin to elucidate the mentioned relationship among different ethnic minorities. Netherland's ethnic diversity includes a large variety of ethnic minorities with different socio-economic and health conditions. Their cultural norms and habits deeply influence their behavior and mobility patterns, and thus excluding this diversity from this study could limit the accuracy and insights offered from the results. At the same time, ensuring ethnic-specific results would allow obtaining a detailed understanding of what causes disproportionate consequences experience by some specific ethnic minorities. The ethnic groups taken into considerations are the ones illustrated in *Chapter 3.2*. However, the 'former Antilles and Aruba' and 'Suriname' groups, which both represent a small percentage of the Netherlands' population, are omitted since their presence would result in strong multicollinearity (>0,7) with most of the 'other non-western immigrant origins' group. Multicollinearity can challenge results from an SEM analysis and cause empirical under-identification of the model (Kelly, 1979); thus, it is important to avoid it to achieve reliable estimates and restrain the possibility of errors. Besides the disaggregation of the non-Dutch ethnic background category, model 2 follows the narrative outlined by the conceptual model (*Figure 5*). The relationships between variables remain the same, and the structure of the model does not vary. *Figure 8* illustrates the simplified and descriptive representation of model 2, while *Figure 9* represents the full version.

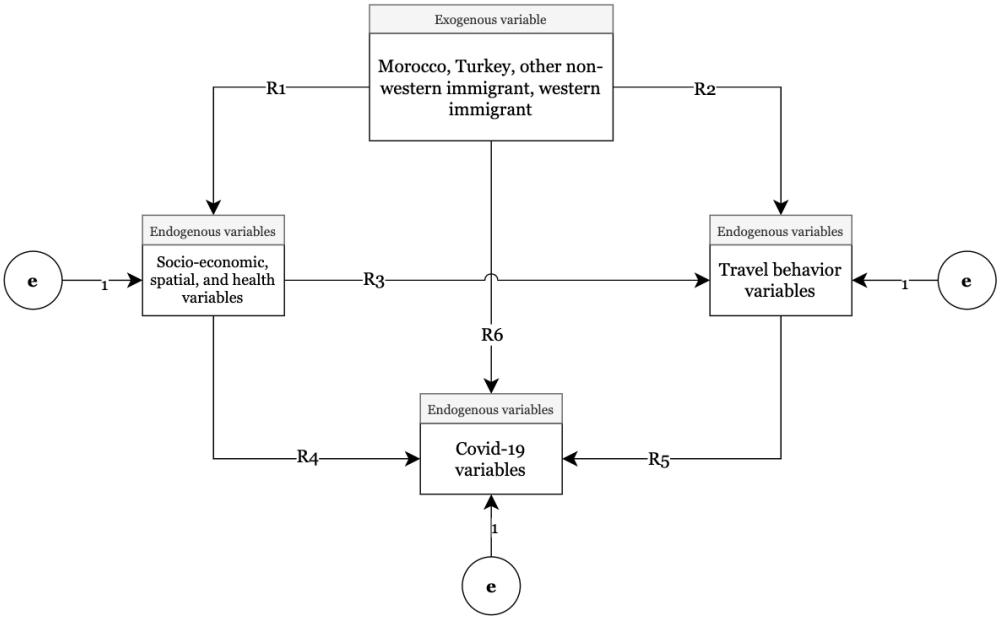



*Figure 8 - Simplified version of model 2 specifications*

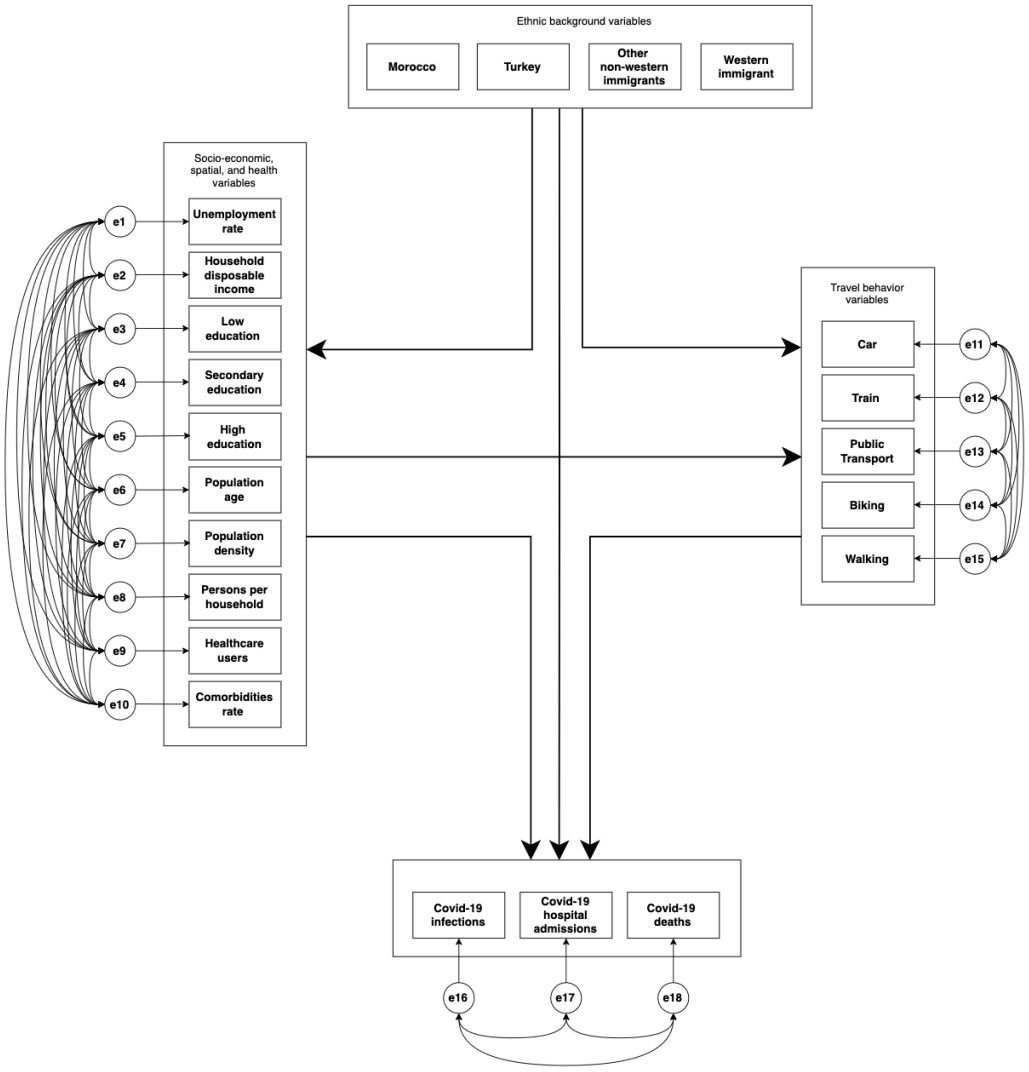



*Figure 9 - Model 2 specifications*

## 4.2. Models Fit

The described models were estimated, and results were gathered. Before analyzing the models' outputs, it is essential to ensure that they have a good fit. Once again, a model fit "determines the degree to which the sample variance-covariance data fit the structural equation model" (Schumacker & Lomax, 2010), and it indicates that the model does not necessarily require any re-specification (Kenny, 2020). A good fitting model is required before analyzing and interpreting any causal path in the model; however, it is important to consider that a good fitting model does not

necessarily translate into a valid model (Kenny, 2020). A model that obtains optimal fitness but lacks theoretical and logical soundness should be avoided.

The model's fit results from each model are summed up in *Table 10,* and only three commonly used model-fit indicators have been taken into consideration, these being: Root-mean-square error of approximation (RMSEA), Comparative fit index (CFI), and Parsimony fit index (PNFI). A further description of the three model-fit indicators, beyond the generic one provided in *Table 8,* is provided in *Table 9*.

*Table 9 - Description of the chosen model-fit indicators*

| Indicator | Interpretation | Acceptable levels |
|---|---|---|
| Chi-square ($\chi 2$ ) | A non-significant (p>0.05) indicates that the variance–covariance matrices are similar, indicating that the theoretical model simnifically reproduces the sample variance–covariance relationships in the matrix | The smaller the better |
| RMSEA | The RMSEA is a badness-of-fit measure, yielding lower values for a better fit, and measures the discrepancy due to the approximation per degree of freedom | .05 to .08 |
| CFI | It measures the relative improvement in fit going from the baseline model to the postulated model | 0 (no fit) to 1 (perfect fit) |
| PNFI | It indicates the model's level of parsimony | 0 (no fit) to 1 (perfect fit) |

*Source: Schumacker & Lomax (2010); Shi, Lee & Maydeu-Olivares (2019)*

According to the chi-square results from the models, all of them demonstrate a perfect fit because all three results are saturated. A saturated model is a model in which all possible parameters are being indicated, and it infers that the best possible fit has been achieved (Schumacker & Lomax, 2010). With all three models being saturated, the root-mean-square error of approximation (RMSEA) is automatically 'zero', indicating an excellent fit for each model. Also, according to the comparative fit index (CFI), all models achieve a great fit, indicating the improvement in fit for all models going from baseline to the proposed models. In conclusion, all three models are saturated, and thus they have an excellent fit, indicating their consistency with the data at identifying relationships between variables. As a result, the models are considered valid, and the model's outputs can be analyzed and interpreted.

*Table 10 - Models fit*

| Model | $X^2$ | df | P-value | RMSEA | CFI | PNFI |
|---|---|---|---|---|---|---|
| Model 1a | 0.000 | 0 | - | 0 | 1 | 0.000 |
| Model 1b | 0.000 | 0 | - | 0 | 1 | 0.000 |
| Model 2 | 0.000 | 0 | - | 0 | 1 | 0.000 |

## 4.3. Model 1a and 1b Results

### 4.3.1. Results on Socio-economic, Health, and Spatial Conditions

Results from model 1a and model 1b confirmed what literature research stated regarding the socio-economic and health disparity between Dutch native and ethnic minorities. The model found polarized results regarding the relationship between ethnic background and socio-economic variables. People with an immigrant background have a strong positive direct relationship with the 'unemployment rate' (β: 0.737) and a negative relationship with 'household disposable income '(β: -0.195), while Dutch natives have the opposite. People with an immigrant background tend to be younger than their Dutch counterparts (β: -0.217) and to live in highly densely populated areas, demonstrated by their strong positive relationship (β: 0.699). It is important to note that, contrarily to what was stated by literature, the model found that people with an immigrant background have a strong negative relationship with the variable 'persons per household', indicating that this segment of the population tends to live in smaller households than their Dutch counterpart.

When it comes to health, the results partly abide by the findings illustrated by the literature in *Chapter 2.9.5.,* finding a significant negative relationship between the 'immigrant origin' group and the 'healthcare users' variables (β: -0.200), indicating that there might be a smaller percentage of health policy-holders (health insurance) among ethnic minorities compared to Dutch natives. However, the relationship between people with immigrant origins and comorbidities rate is insignificant (β: -0.025) and does not align with what is described by literature. Surprisingly, the results that emerged from the relationship between ethnic groups and education largely diverge from initially thought. While literature pressed on the notion that people with an immigrant background covered more blue-collar positions because of their low education and disadvantaged economic conditions (Ministers van Onderwijs, Cultuur en Wetenschap, 2019), the model found that the portion of the workforce with an immigrant background is more likely to hold a higher education diploma (ex. WO) (β: 0.359). On the other hand, the Dutch native workforce is more like to have a low (β: 0.295) and secondary (β: 0.350) level of education. The reason behind this incoherence is unclear.

The results on travel behavior differences between Dutch native and people with an immigrant background align with what the consulted Dutch-based travel behavior studies found, like the one from Harms (2008). Dutch natives are much more likely to bike over any other means of transport, as shown by the results in *Table 11*. The only positive relationship between Dutch natives and a means of transport is with biking (β: 0.772), while the relationship with other means of transport is found to be negative, especially in the case of public transport (β: -0.531). On the other hand, as described in *Chapter 2.10.*, ethnic minorities are much more likely to use public transport (β: 0.675), mass transport (train) (β: 0.560), and cost-less means of transport like walking (0.463). The model also found a significant negative relationship with car usage (β: -0.272) and biking (β: -0.245), likely due to economic reasons for the former (Oakil et al., 2016; Karen et al., 2019) and cultural incompatibilities with the latter (Harms, 2008).

*Table 11 - Standardized total effects (model 1a/b)*

| | Immigrant Origins | Dutch Native |
|---|---|---|
| **Population age** | -0.217 | 0.217 |
| **Workforce with a high education** | 0.359 | -0.359 |
| **Workforce with a secondary education** | -0.350 | 0.350 |
| **Workforce with a low education** | -0.295 | 0.295 |
| **Comorbidities rate** | -0.025 | 0.025 |
| **Healthcare users** | -0.200 | 0.200 |
| **Persons per household** | -0.599 | 0.599 |
| **Population Density** | 0.699 | -0.699 |
| **Household disposable income** | -0.195 | 0.195 |
| **Unemployement rate** | 0.737 | -0.737 |
| **Walking** | 0.463 | -0.463 |
| **Biking** | -0.245 | 0.245 |
| **Public Transport** | 0.675 | -0.675 |
| **Train** | 0.560 | -0.560 |
| **Car** | -0.272 | 0.272 |

## Summary

*Results from model 1a and model 1b align with the socio-economic and health disparity notions discussed in Chapter X. People with an immigrant background are more likely to suffer from socio-economic disadvantages and lower health care usage. Surprisingly, these results show that people with an immigrant background are more likely to live in smaller households - something that diverges with what found in literature.*

*Furthermore, results confirm that ethnic minorities are more likely to use public transport and walking than their Dutch counterparts, who are more likely to bike due to cultural influence and use privileged means of transport like private cars. This stark disparity in travel behavior might be sourced from economic disparity and cultural differences.*

### 4.3.2. Relative Effect of Travel Behavior Variables on Covid-19 Variables

As discussed in *Chapter 2.6*, studies have found that Covid-19 related health disparity can be partially sourced to the usage of public transport (McLaren, 2020). This information has alimented the idea that, to some degree, there could be a relationship between travel behavior and Covid-19 records. However, model 1a/b did not confirm this theory. Results from the direct relationship between travel behavior and Covid-19 records unveil that their relationship is weak and that travel behavior is an insignificant predictor of Covid-19 related health implications, with the only exception being the relationship between walking and Covid-19 hospital admissions (β: 0.253). This goes to indicated that, according to the model, different travel behaviors do not significantly impact Covid-19 records and Covid-19 implications might not be sourced directly to differences in mobility styles. However, it is important to keep in mind, as mentioned in *Chapter 3.4,* that the lack of recent mobility datasets collected during the Covid-19 pandemic might have had an impact on the results, considering that, according to various empirical studies, the pandemic has altered the travel's modal split (Medimorec et al., 2020; Abdullah et al. 2020; de Haas et al., 2020) and the safety perception related to different means of mobility (Barbieri et al., 2021). Notably, the relationship between walking and Covid-19 records - especially Covid-19 hospital admissions (β: 0.253) - appears to be significant and implicates a relationship between the number of people choosing to walk as a means of mobility and the number of Covid-19 hospital admissions. This significant relationship could be explained by the fact that 'walking' can be considered as a proxy for 'population density', where it is common to register a higher number of Covid-19 infections, hospital admissions, and deaths; however, this model already controls for 'population density' indicating that the positive relationship between 'walking' and Covid-19 variables is not a result of 'population density'. It might be that the included density does not fully capture all dimensions of density, and this positive relationship between 'walking' and Covid-19 variables might be a residual effect of population density.

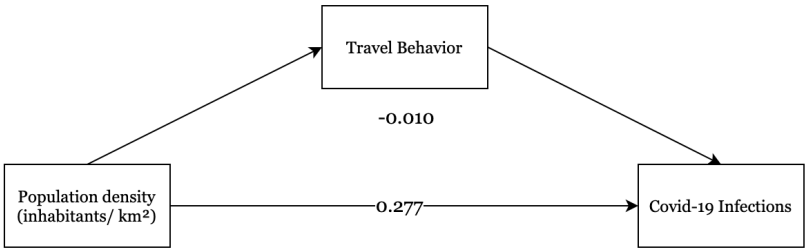
*Table 12 - Standardized total effects of travel behavior and Covid-19 variables (model 1 a/b)*

| | Walking | Biking | Public Transport | Train | Car |
|---|---|---|---|---|---|
| **Covid-19 infections** | 0.145 | -0.066 | -0.115 | -0.057 | 0.067 |
| **Covid-19 hospital admissions** | 0.253 | -0.057 | 0.051 | -0.107 | 0.190 |
| **Covid-19 Deaths** | 0.113 | 0.006 | -0.050 | -0.082 | 0.173 |

Contrarily, the relationships between socio-economic, spatial, and health variables with Covid-19 related variables offer several points worthy of reflection. First of all, the relationship between these variables and Covid-19 variables is either direct, referring to the notion that disadvantaged socio-economic conditions have been linked to a higher incidence of Covid-19 implications (Abedi et al., 2020; Wiemers et al., 2020; Yaya et al., 2020; Wiemers et al. 2020; Torrats-Espinosa, 2021), or indirect via different travel behaviors - based on studies that found a significant portion of Covid-19 related health disparity being sourced to the use of public transport (McLaren, 2020). Just like the results from the direct relationship between travel behavior and Covid-19 records, the indirect relationships of socio-economic, spatial, and health variables with travel behavior acting as a mediating variable are found to be insignificant, indicating that the relationship between these variables and Covid-19 related implications can not be sourced to the way socio-economic variables influence travel behavior and subsequently Covid-19 infections, hospital admissions, and

deaths. For example, as shown in *Figure 6*, the total effect of population density - a spatial variable that indicates the number of inhabitants per km² - on Covid-19 infections is merely due to the direct relationship between mentioned variables; instead, the indirect relationship appears to be insignificant, potentially indicating that travel behavior does not mediate the path between population density and Covid-19 infections. To summarize, the significant positive relationship between population density and Covid-19 is not explained by differences in travel behavior but because higher rates of population density are associated with a higher level of Covid-19 infections.

*Figure 10 - Total, direct, and indirect relationship between population density (independent variables) and Covid-19 infections (dependent variables) with Travel Behavior acting as a mediator*




**Total Standardized Effect:** 0.267

Just like in the case illustrated in *Figure 10*, other socio-economic and spatial variables have a strong positive total relationship with Covid-19 variables (merely resulting from the direct portion of the relationships). Within the education domain, the model suggests that the relationship between education and Covid-19 infections strengthens as the level of educations decreases, going from (β: -0.139) in the case of 'workforce with high educations' as an independent variable to (β: 0.209) when the education level is low. Thus, a low level of education could be a predictor of higher rates of Covid-19 infections. Health-related variables (comorbidities rate and healthcare users (β: -0.039)) are found to be a not significant predictor of Covid-19 infection, hospital admission, and death rates, with comorbidities rate demonstrating a slightly negative effect on Covid-19 infections (β: -0.163). An interpretation of these results can be that people with preexisting conditions - such as people suffering from one or more chronic diseases - might choose to adopt a cautious lifestyle during the Covid-19 pandemic, reducing the chances of coming in contact and contract the infectious disease. Among the socio-economic variables, 'unemployment rate' is the only one with a significant effect on Covid-19 variables; however, counterintuitively, the effect is negative with both Covid-19 infections (β: -0.142) and hospital admission (β: -0.219), indicating that (in the case of hospital admissions) when unemployment goes up by one standard deviation, Covid-19 hospital admissions goes down by 0.219 standard deviations. This finding goes counter-current from findings elucidated by some American-based studies (Yaya et al., 2020). Finally, returning to the section of results depicted in *Figure 10*, spatial variables seem to have the strongest effect on Covid-19 variables. Indeed, the model found a considerable positive relationship between spatial variables (population density and persons per household) and Covid-19 variables, as shown by the standardized total effects results (*Table 13)*. The disproportionate effect of spatial variables on Covid-19 variables, when compared to other socio-economic, health, and mobility variables, might suggest that these variables have a key role in the outcomes and development of Covid-19 among Dutch municipalities, much more than any other variable that has been taken into consideration in this study.

*Table 13 - Standardized total effects between mediating variables and Covid-19 variables (model 1 a/b)*

| | Population age | high education | secondary education | low education | Comorbidities rate | Healthcare users | Persons per household | Population Density | Household disposable income | Unemployment rate |
|---|---|---|---|---|---|---|---|---|---|---|
| **Covid-19 infections** | -0.051 | -0.139 | 0.136 | 0.209 | -0.163 | -0.039 | 0.355 | 0.267 | 0.026 | -0.142 |
| **Covid-19 hospital admissions** | 0.180 | -0.014 | 0.099 | 0.075 | 0.087 | -0.072 | 0.332 | 0.107 | -0.076 | -0.219 |
| **Covid-19 Deaths** | 0.312 | -0.030 | -0.042 | 0.043 | 0.086 | 0.020 | 0.293 | 0.274 | 0.009 | 0.039 |

*Table 14 - Standardized direct effect between mediating variables and Covid-19 variables(model 1 a/b)*

| | Population age | high education | secondary education | low education | Comorbidities rate | Healthcare users | Persons per household | Population Density | Household disposable income | Unemployment rate |
|---|---|---|---|---|---|---|---|---|---|---|
| **Covid-19 infections** | -0.113 | -0.117 | 0.121 | 0.185 | -0.197 | -0.018 | 0.347 | 0.277 | 0.051 | -0.085 |
| **Covid-19 hospital admissions** | 0.059 | 0.023 | 0.068 | 0.050 | 0.033 | -0.034 | 0.289 | 0.111 | -0.036 | -0.156 |
| **Covid-19 Deaths** | 0.233 | -0.021 | -0.087 | 0.022 | 0.036 | 0.033 | 0.251 | 0.298 | 0.014 | 0.084 |

*Table 15 - Standardized indirect effect between mediating variables and Covid-19 variables(model 1a/b)*

| | Population age | high education | secondary education | low education | Comorbidities rate | Healthcare users | Persons per household | Population Density | Household disposable income | Unemployment rate |
|---|---|---|---|---|---|---|---|---|---|---|
| **Covid-19 infections** | 0.063 | -0.022 | 0.015 | 0.024 | 0.034 | -0.021 | 0.008 | -0.010 | -0.025 | -0.056 |
| **Covid-19 hospital admissions** | 0.121 | -0.037 | 0.031 | 0.025 | 0.054 | -0.038 | 0.043 | -0.004 | -0.040 | -0.063 |
| **Covid-19 Deaths** | 0.079 | -0.008 | 0.045 | 0.021 | 0.050 | -0.013 | 0.041 | -0.024 | -0.005 | -0.045 |

## Summary

*Results from model 1a and model 1b disagree with the notion that Covid-19 related health disparity can be partially sourced to public transport usage. Results show that public transport is an insignificant predictor of Covid-19 related health implications, while walking appears to be the only "means of transport" to significantly correlate with Covid-19 hospital admissions.*

*Furthermore, results show that different travel behaviors are weak mediators between socio-economic, health, and spatial variables and Covid-19 variables (infections, deaths, and hospital admissions). Instead, the mentioned relationships are sourced to their direct portion of the relationship. The main insights from these significant direct relationships are: a low level of education could be a predictor of higher rates of Covid-19 infections; among the socio-economic variables, 'unemployment rate' is the only one with a significant effect on Covid-19 variables, however, surprisingly the relationship is negative with both Covid-19 infections and hospital admission; people living in densely populated areas are significantly more likely to suffer from Covid-19 implications, while people living and in crowded household are much less likely.*

### 4.3.3. Relationship Between Ethnic Background and Covid-19

In accordance with the consulted literature, the model confirms the notion that ethnic minorities are disproportionately affected by Covid-19 than their Dutch counterpart. As shown in *Table 16*, this disparity in Covid-19 related outcomes between Dutch natives and non is merely embodied by their direct relationship. In fact, the direct relationship between 'immigrant origins' and Covid-19 infections (β: 0.227) and hospital admissions (β: 0.358) is positive and significant, indicating that ethnic minorities might be disproportionally impacted by Covid-19 when compared to Dutch native, whose direct relationship with Covid-19 variables is equal in magnitude yet opposite in sign. On the other hand, the indirect relationship between people with immigrant background and Covid-19 infections (β: -0.238) and hospital admissions (β: -0.187) is negative, indicating that the socio-economic, spatial, health, and TB variables do not positively mediate the path between ethnic background and Covid-19 variables. Thus, the relationship between ethnic minorities and Covid-19 related implications is direct, and the identified disparity in health outcome between Dutch native and ethnic minorities might be due to things that have not been included in the model.

*Table 16 - Standardized effects of ethnic background on Covid-19 variables*

| | Dutch native | | | People with immigrant origins | | |
|---|---|---|---|---|---|---|
| | **Standardized total effect** | **Standardized direct effect** | **Standardized indirect effect** | **Standardized total effect** | **Standardized direct effect** | **Standardized indirect effect** |
| **Covid-19 infections** | 0.011 | -0.227 | 0.238 | -0.011 | 0.227 | -0.238 |
| **Covid-19 hospital admissions** | -0.171 | -0.358 | 0.187 | 0.171 | 0.358 | -0.187 |
| **Covid-19 deaths** | -0.086 | -0.087 | 0.001 | 0.086 | 0.087 | -0.001 |

**Summary**

*Results from models 1a and 1b confirm that ethnic minorities are more likely to suffer Covid-19 infections and hospital admissions, but no deaths. Their relationship stems from the direct portion of the relationship and not the indirect relationship that involved the role of the mediating variables. This suggests that the identified disparity in health outcomes between Dutch native and ethnic minorities might not be related to their socio-economic conditions, travel behavior, and so forth, but due to things that have not been included in the model.*

## 4.4. Model 2 Results

As mentioned in chapter 4.1.2., model 2 disaggregates the ethnic group' immigrant origins' into the most populous ethnic minority groups residing in the Netherlands. The results will be analyzed and compared between the ethnic minority groups. During the modeling process, path analysis requires all the exogenous variables, in this case, the ethnic minority groups, to be correlated; a double-headed arrow represents this correlation. The results from model 2 show a weak (<0.7) correlation between the exogenous variables, demonstrating that there is no multicollinearity

between exogenous variables. However, it is essential to mention that the 'Morocco' ethnic group has a considerable correlation with both the 'Turkey' ethnic group and 'other non-western immigrants'. As a result, the model might suffer from these correlations and fail to accurately predict the specific effects of the Morocco ethnic group on socio-economic, health, spatial, TB, and Covid-19 variables.

*Table 17 - Correlation results between exogenous variables (model 2)*

| Correlations | Values |
|---|---|
| Morocco <—> Turkey | 0.485 |
| Morocco <—> Other non-western immigrant | 0.562 |
| Morocco <—> Western immigrant | 0.303 |
| Turkey <—> Other non-western immigrant | 0.521 |
| Western immigrant <—> Turkey | 0.245 |
| Western immigrant <—> Other non-western immigrant | 0.481 |

### 4.4.1. Results on Socio-economic, Health, and Spatial Conditions

Results from model 2 further confirm the disadvantageous socio-economic conditions of ethnic minorities in the wake of model 1a/b results. All ethnic minorities experience higher rates of unemployment (e.g., Turkey ethnic minority has a significant positive relationship with the unemployment rate (β: 0.286)) except the Morocco ethnic minority, which shows an insignificant relationship with both the variable 'unemployment rate' (β: 0.064) and 'household disposable income' (β: 0.017). Additionally, Turkish ethnic minorities experience lower disposable income levels, highlighted by their strong negative relationship (β: -0.351).

Model 2 highlights that there is also a disparity in education level within the 'people with an immigrant background' group. While 'other non-western immigrants' (β: 0.433) (such as people from Asia, Africa, and more) and 'Morocco' (β: 0.238) have a strong positive relationship with high education, the 'Turkey' ethnic minority group (β: -0.141) results from having a negative relationship, indicating that municipalities with a higher rate of people with a Turkish background might register higher rates of workforce with a secondary to low education level. The relationship between 'other non-western immigrant' and 'Morocco' tend to become negative as the education level decrease, whereas the opposite happens for the 'Turkey' ethnic group.

Results on the relationship between ethnic minority groups and spatial variables align with the findings anticipated by model 1a/b. Most ethnic minority groups, except western immigrants (β: 0.025), have a strong significant relationship with population density, especially for the 'other non-western immigrant' minority group that yields a (β: 0.463) direct relationship. Furthermore, model 2 also confirms the counterintuitive findings yielded by model 1a/b regarding ethnic minorities having a strong negative relationship with 'number of persons per household'. In fact, both 'other non-western' (β: -0.202) and 'western' (β: -0.488) ethnic minorities display significant negative

relationships, whereas both 'Turkey' and 'Morocco' ethnic minority group results are insignificant. These results indicate that these ethnic minorities tend to live in densely populated areas like cities and live in smaller households.

When it comes to health, model 2 results partially align with model 1a/b ones. While the model confirms model 1a/b results regarding the negative relationship between ethnic minorities and 'healthcare users', model 2 provides interesting findings concerning the 'comorbidities rates' between ethnic minority groups. Interestingly, disparity is recorded in the relationship between ethnic minority groups and 'comorbidities rate'; 'other non-western immigrant' (β: -0.395) and 'Morocco' (β: -0.125) ethnic minorities resulted in having a significant negative relationship with 'comorbidities rate', whereas the opposite is registered for the 'Turkey' (β: 0.219) and 'Western immigrant' (β: 0.319) ethic minority groups. It is not clear the motives behind this health disparity within the immigrant background segment of the population; however, this study will only analyze empirical studies for this section of results and avoid any further interpretation.

*Table 18 - Standardized total effects between ethnicity and mediating variables (Model 2)*

| | Other non-western immigrant | Turkey | Western Immigrant | Morocco |
|---|---|---|---|---|
| **Population age** | -0.448 | -0.051 | 0.473 | -0.264 |
| **Workforce with a high education** | 0.433 | -0.141 | -0.073 | 0.238 |
| **Workforce with a secondary education** | -0.250 | 0.122 | -0.158 | -0.147 |
| **Workforce with a low education** | -0.308 | 0.143 | -0.143 | -0.031 |
| **Comorbidities rate** | -0.395 | 0.219 | 0.319 | -0.125 |
| **Healthcare users** | -0.118 | 0.047 | -0.048 | -0.116 |
| **Persons per household** | -0.202 | -0.094 | -0.488 | 0.013 |
| **Population Density** | 0.463 | 0.120 | 0.025 | 0.295 |
| **Household disposable income** | 0.113 | -0.351 | -0.098 | 0.017 |
| **Unemployement rate** | 0.379 | 0.286 | 0.223 | 0.064 |
| **Walking** | -0.005 | 0.061 | 0.317 | 0.245 |
| **Biking** | 0.182 | -0.013 | -0.462 | 0.007 |
| **Public Transport** | 0.593 | -0.061 | 0.158 | 0.055 |
| **Train** | 0.324 | 0.091 | 0.014 | 0.337 |
| **Car** | -0.339 | -0.017 | 0.159 | -0.159 |

Disaggregating the immigrant background segment allowed to obtain a detailed and ethnic-specific understanding of different travel behaviors among ethnic minorities. While model 1a/b showed that people with an immigrant background are less likely to drive a car as a means of transport, model 2 provides a more elaborated analysis of car usage among ethnic minorities. Most non-western ethnic groups (e.g., other non-western immigrants (β: -0.339) and Morocco (β: -0.159)) have a negative relationship with car usage, whereas the relationship becomes positive for western immigrants. This car usage distinction could be related to socio-economic and cultural

differences, as described by subdividing standardized total effects into direct and indirect - via socio-economic, health, and spatial variables - described respectively in *Table 29* and *Table 30* located in the Appendix. Public transport is still a leading mobility option for different ethnic minority groups, however, the appeal to public transport varies among each minority group. For example, the ethnic group 'other non-western immigrant' has a strongest positive relationship with 'public transport' (β: 0.593), followed by 'western immigrant' (β: 0.158). On the other hand, the remaining ethnic minority groups (Turkey and Morocco) have an insignificant relationship with public transport. Results showed no interesting insights in the travel behavior preferences of he ethnic group 'Turkey', since all relationships resulted to be insignificant.

**Summary**

*Results from mode 2 aimed at analyzing the relationship between ethnicity and the mediating variables (socio-economic, education, and spatial) align with the ones elucidated by model 1a/b. People with an immigrant background are more likely to suffer of socio-economic disadvantageous, and some of them have strong positive relationship with high level of education. Interestingly, the model found that there is disparity in the socio-economic conditions and education levels between ethic minority groups. For example, people with a Turkish background, among all the ethnic minority groups, are the worse-off economically and experience lower education rates. This registered disparity also continues in the relationship ethnic minority groups and spatial and health variables.*

*When it comes to travel behavior, results showed that western immigrants are more interested in using cars than any other ethnic minority group. The registered appeal to public transport also varies, with the main groups non-western immigrants and western-immigrants being more likely to use public transport.*

### 4.4.2 Relative Effect of Travel Behavior Variables on Covid-19 Variables

As shown by *table 19,* which shows the standardized total effects between travel behavior variables and Covid-19 variables, model 2 reaffirms the findings yielded by model 1a/b where travel behavior is an insignificant predictor of Covid-19 related health implications. This model also shows some exceptions in line with the ones hightailed in the previous models. The first exception is that, just like in model 1a/b, 'walking' appears to be the only travel behavior variable that considerably affects Covid-19 related variables - especially with hospital admissions (β: 0.197). The second interesting exception is the one registered by the relationship between 'car' and Covid-19 hospital admissions (β: 0.179) and deaths (β: 0.179). These results build upon model 1a/b results to confirm the notion that this study does not consider travel behavior to have a key role in the impact of Covid-19 among Dutch municipalities.

*Table 19 - Standardized total effect - relationships between travel behavior and Covid-19 variables*

| | Walking | Biking | Public Transport | Train | Car |
|---|---|---|---|---|---|
| **Covid-19 infections** | 0.110 | -0.094 | -0.080 | -0.090 | 0.041 |
| **Covid-19 hospital admissions** | 0.197 | -0.064 | 0.121 | -0.137 | 0.179 |
| **Covid-19 Deaths** | 0.100 | 0.021 | -0.023 | -0.092 | 0.179 |

Model 2 also confirms the results and the derived interpretations of model 1a/b. While socio-economic (' unemployment rate' and 'household disposable income') and health variables ('comorbidities rate' and 'healthcare users') do not have a significant relationship with Covid-19 variables, results related to education, age, and spatial variables align with the ones yielded by model 1a/b. Age is still a key indicator of Covid-19 deaths (β: 0.296), and the role of education in the intensity of Covid-19 related implications strengthens as the level of educations decreases. In fact, the relationship with 'Covid-19 infections' goes from a negative relationship in the case of 'high education' (β: -0.154) to a positive one with 'low education' (β: 0.196). The strongest predictors of Covid-19 infections, hospital admissions, and deaths remain the spatial variables. Just like in model 1a/b, both 'persons per household' and 'population density' have a strong positive relationship with every Covid-19 variable, reaffirming the notion that densely populated areas with a high number of big households might suffer more from the pandemic. The majority of these relationships' total effects merely come from the direct relationship, whereas all the indirect relationships between socio-economic, health, and spatial variables result insignificant. This reaffirms the idea that travel behavior does not mediate the path between socio-economic, health, and spatial conditions and Covid-19 implications.

*Table 20 - Standardized total effects - relationships between socio-economic, health, spatial and Covid-19 variables*

| | Population age | high education | secondary education | low education | Comorbidities rate | Healthcare users | Persons per household | Population Density | Household disposable income | Unemployement rate |
|---|---|---|---|---|---|---|---|---|---|---|
| **Covid-19 infections** | -0.052 | -0.154 | 0.156 | 0.196 | -0.180 | -0.042 | 0.335 | 0.256 | 0.063 | -0.126 |
| **Covid-19 hospital admissions** | 0.181 | -0.032 | 0.131 | 0.067 | 0.030 | -0.068 | 0.349 | 0.141 | -0.055 | -0.093 |
| **Covid-19 Deaths** | 0.296 | -0.029 | -0.031 | 0.035 | 0.069 | 0.021 | 0.299 | 0.277 | 0.019 | 0.059 |

*Table 21 - Standardized indirect effects - relationships between socio-economic, health, spatial and Covid-19 variables*

| | Population age | high education | secondary education | low education | Comorbidities rate | Healthcare users | Persons per household | Population Density | Household disposable income | Unemployement rate |
|---|---|---|---|---|---|---|---|---|---|---|
| **Covid-19 infections** | 0.056 | -0.023 | 0.026 | 0.019 | 0.028 | -0.019 | 0.033 | 0.003 | -0.015 | -0.020 |
| **Covid-19 hospital admissions** | 0.127 | -0.036 | 0.041 | 0.024 | 0.043 | -0.033 | 0.094 | 0.021 | -0.039 | 0.004 |
| **Covid-19 Deaths** | 0.069 | -0.006 | 0.049 | 0.019 | 0.042 | -0.011 | 0.051 | -0.012 | -0.002 | -0.022 |

*Table 22 - Standardized direct effects - relationships between socio-economic, health, spatial and Covid-19 variables*

| | Population age | high education | secondary education | low education | Comorbidities rate | Healthcare users | Persons per household | Population Density | Household disposable income | Unemployement rate |
|---|---|---|---|---|---|---|---|---|---|---|
| **Covid-19 infections** | -0.108 | -0.131 | 0.131 | 0.176 | -0.208 | -0.023 | 0.303 | 0.253 | 0.077 | -0.106 |
| **Covid-19 hospital admissions** | 0.054 | 0.004 | 0.090 | 0.043 | -0.013 | -0.035 | 0.254 | 0.120 | -0.017 | -0.097 |
| **Covid-19 Deaths** | 0.227 | -0.023 | -0.080 | 0.016 | 0.026 | 0.032 | 0.248 | 0.290 | 0.020 | 0.081 |

**Summary**

*Model 2 confirms that travel behavior is an insignificant predictor of Covid-19 related implications, with 'walking' and 'car' being the only two exceptions. 'Walking' is linked to higher Covid-19 hospital admissions, while 'car' with both hospital admissions and deaths.*

*Furthermore, model 2 shows that age is a key indicator of Covid-19 deaths and that the gravity of Covid-19 implications increases as the level of educations decreases. People with low educations get more infected. Spatial variables remain the strongest predictors of Covid-19 infections, hospital admissions, and deaths. Most of these results align with the ones yielded by model 1a/b.*

### 4.4.3. Relationship Between Ethnic Background and Covid-19

While model 1a/b reported that ethnic minorities, seen as a whole ethnic group, are disproportionally affected by Covid-19 than their Dutch counterpart, model 2 highlights that this registered health disparity varies between ethnic minority groups. 'Morocco' is the included ethnic minority that appears to experience higher rates of Covid-19 infections (β: 0.201) and related hospital admissions (β: 0.245), both significant positive relationships. The ethnic minority groups' Turkey' also has a positive but weak relationship solely with Covid-19 infections (β: 0.105). Although the standardized total path coefficient results are weak, it still shows that such ethnic minorities might experiment higher Covid-19 infections rate. On the other hand, the ethnic group 'western immigrant' results to be a negative predictor of Covid-19 infections (β: -0.163); however, the relationship becomes positive with Covid-19 hospital admissions (β: 0.208) and Covid-19 deaths (β: 0.158). This might indicate that western immigrant experience less rates of Covid-19 infections, however, once infected they experiences more serious implications and higher death rates. The last ethnic minority included in this study, 'Other non-western immigrant' appears to be the least affected by Covid-19, registering a significant negative relationship with 'Covid-19 hospital admissions' (β: -0.225) and 'Covid-19 deaths' (β: -0.145) but insignificant with 'Covid-19 infections' (β: -0.097).

Just like in model 1a/b, the majority of each mentioned relationship (effect) can be sourced to the direct portion of the relationship, showing the weak role of the intermediating variables as path mediators (e.g., the magnitude of the effect between 'Morocco' and Covid-19 variables is given by their direct relationship). However, there are few significant exceptions. In the case of the negative relationship between 'western immigrant' and Covid-19 infections, its negative effect is merely a result of their indirect relationship, which results to be significant. A potential reason behind this is the role of mediators that spatial variables could have played in this relationship. The spatial variables' persons per household' are found to be the strongest predictors of Covid-19 implications

(especially for Covid-19 infections), and western immigrant' is the ethnic groups with the strongest (negative) relationship with 'persons per household' (β: -0.488). As a result, western immigrants' tendency to be part of smaller households could have favored their probability of infection.

*Table 23 - Standardized total effects - ethnicity and Covid-19 variables*

| | Other non-western immigrant | Turkey | Western Immigrant | Morocco |
|---|---|---|---|---|
| **Covid-19 infections** | -0.097 | 0.105 | -0.163 | 0.201 |
| **Covid-19 hospital admissions** | -0.225 | 0.036 | 0.208 | 0.245 |
| **Covid-19 Deaths** | -0.145 | 0.079 | 0.158 | 0.059 |

*Table 24 - Standardized direct effects - ethnicity and Covid-19 variables*

| | Other non-western immigrant | Turkey | Western Immigrant | Morocco |
|---|---|---|---|---|
| **Covid-19 infections** | -0.003 | 0.138 | 0.091 | 0.141 |
| **Covid-19 hospital admissions** | -0.096 | 0.069 | 0.209 | 0.255 |
| **Covid-19 Deaths** | -0.051 | 0.065 | 0.084 | 0.062 |

*Table 25 - Standardized indirect effects - ethnicity and Covid-19 variables*

| | Other non-western immigrant | Turkey | Western Immigrant | Morocco |
|---|---|---|---|---|
| **Covid-19 infections** | -0.094 | -0.033 | -0.254 | 0.060 |
| **Covid-19 hospital admissions** | -0.129 | -0.032 | -0.001 | -0.010 |
| **Covid-19 Deaths** | -0.095 | 0.015 | 0.074 | -0.003 |

## Summary

*While model 2 confirms the idea that ethnic minorities disproportional fell victims of Covid-19, there is disparity in the infections and healthcare outcomes within the 'people with an immigrant background' segment. This disparity can be merely sourced to the direct relationship between ethnic minorities and Covid-19 variables, belittling the role of socio-economic, health, and travel behavior variables as path mediators. However, the number of persons per household - a spatial variable - could be a significant mediator between ethnic background and Covid-19 implications and could bear the responsibility of disparities in Covid-19 infections rates between ethnic minority groups.*

# 5. Transport Covid-19 Related Policy Analysis

Although results from this study underlined the insignificance of the role of public transport in the development of the Covid-19 pandemic and the healthcare outcome disparity suffered by ethnic minorities, policymakers remain wary of leaving public transport restrictions-free during a health crisis. Throughout the pandemic, a set of restrictive measures had either direct or indirect implications on public transport and its riders, with the end goal of minimizing mobility and lessening the dissemination of the novel virus; however, researchers are divided on the actual effectiveness of such measures. This chapter aims to shed light on the restrictive policies that impacted public transport usage in the Netherlands, their efficacy, and the governance structure behind them. This analysis will be used to propose alternative ways for authorities and public transport providers to treat public transport during a nationwide health crisis.

Having access to Netherlands-specific or municipality-specific Covid-19 emergency response is no easy matter. The majority of information regarding the series of transport policies and measures adopted as a consequence of Covid-19 and the same used to avert mobility and health disparity between ethnic groups have not been made publicly available by different public authorities. As a result, this policy analysis is merely based on publicly available information, and it is not tailored to a specific type of municipality; instead, this analysis is channeled toward Dutch public authorities - this includes policymakers, municipalities, transport authorities, and so on - and researchers that are interested in persevere in finding reasons behind health disparity during a health crisis and the role that transportation plays in it. In the following sub-chapters, the set of key actors involved in the decision-making process of Covid-19 related transport policies and the transport governance during a health crisis will act as an introduction to the analysis on the transport policies in response to the pandemic and their relative effectiveness, followed by the transport policy interventions intended to provide alternatives to the current restrictive approaches used to manage transport services during a pandemic.

## 5.1. Actors Involved in the Covid-19 Related Transport Policies

Before analyzing the series of policies and interventions employed to curb the health and socio-economic implications of Covid-19, it is imperative to understand the legislative and private bodies that develop and enforce these directives. *Table 26* provides a quick overview of the actors directly or indirectly involved in the Covid-19 transport crisis management and a brief description of their general role. The list of key actors that are at the base of any decision-making within the Dutch public transport domain can be classified between public or private entities; however, the only exception is for the public transport operators that differ between different municipalities or provinces and whose governance is generally delegated to city-owned or private operators (Rye et al., 2018).

*Table 26 - Actors involved in the government of public transport*

| Actor | Type | General Role |
|---|---|---|
| Municipalities | Local public authority | The municipal government oversees the operations and functions of the city and its boroughs. It manages funds provided by regional or national authorities to invest on public transport. It is responsible of providing a wide-range of services to citizens, such as public transportation, while ensuring their viability, security and development in line with regional and national objectives. |
| Government of the Netherlands | National public authority | The government provides founds for national roads, railway systems, regional/ provincial/local transport solutions and manages these systems, providing maintenance, capacity management, and means for expansion and development. It collects majority (96%) of tax revenue that later spends on central (68.4%) and local (31.6%) projects (OECD Statistics, 2017). It holds significant decision-making in the trajectory of policies in public transport and it is responsible to drive national transport solutions (Wijnand & Mulley, 2018) |
| Provincial executive | Regional public authority | They represent the middle tier between municipalities and government. They hold key formal responsibility for the governance and planning of local and regional public transport. They also manage subsidies destined for provincial transport authorities (Rye et al., 2018) |
| Nederlandse Spoorwegen | State owned rail transport authority | It is the Dutch state-owned rail provider which connects all major towns in the Netherlands. It is also in charge and responsible for the safety of its services and his passengers. |
| Public transport operators | Local public transport authority | In the Netherlands buses, trams, and metros are operated on a directly awarded or competitive contract by a mixture of a city-owner or private operators (Rye et al., 2018). They provide city and intercity mobility services to citizens, while ensuring the efficiency and safety of their services. |

Public authorities are institutional bodies that hold administrative power in the service of public interests. They have various levels of authority. In the case of the Netherlands, they go from central authority embodied by the government of the Netherlands to local authorities, constituted by provides (Zuid-Holland) and municipalities (e.g., Rotterdam). As described in *Table 26*, the central government is the pivotal decision-maker in public transport, and it is the body that drives the majority of multi-level transport policies and innovations; it is also the institutional body that orchestrates national response to a major crisis and has to adapt every socio-economic layer to the implications brought by this event. In the case of Covid-19, the Dutch government - represented by the ministry of health, welfare, and sport and by the ministry of transport and water management -

directed the national response to the calamitous health and socio-economic repercussions of the pandemic. These authorities coordinated the national effort and maintained continuous contact with the municipal health services (GGDs), which carried out the operations on a regional level following the national authorities' guidelines (FRA, 2020). Since early March, the Dutch government introduced several stringent measures that impacted public transport and the travel behavior of the individuals, among which the followings are the most consequential: stay-at-home restrictions, cancellation of public events and gatherings, face covering, limitations of domestic travel, and school and workplace closure (Roser et al., 2020). These various measures have been imposed nationally, regionally, and locally and functioned as guidelines for local transport responses to Covid-19.

Regional and local authorities had the intermediating role of adapting national emergency policies and measures to their specific environment and infrastructure and enforcing them to the public. In the event of a crisis, such as the Covid-19 pandemic, their executive power is granted by the Public Health Act (The Netherlands, 2008) and the Dutch Safety Regions Act (Wet veiligheidsregio's) (The Netherlands, 2010), which give extensive powers to the mayor of the central municipality of the Safety Regions (Veiligheidsregio's) enabling them to take several public order measures in the whole region to fight or prevent disasters (e.g., limit transpiration, restrict a public area and so on) (FRA, 2020). This structured and premeditated emergency framework of collaboration between national and regional/local authorities resulted crucial at ensuring cross-regional strategic consistency and at architecting a harmonious multi-dimensional tactic to fight the spread of the virus; however, the strenuous socio-economic implications of such stringent measures faced harsh resistance by both local/regional authorities and citizens throughout their course.

When it comes to public transport operators, their governance varies depending on the extension of the infrastructure and service. Nederlandse Spoorwegen (NS), the national rail operator, is state-owned, and decisions affecting NS's operation and services are directly linked to the government's objectives. On the other hand, local public transport providers, like Rotterdamse Elektrische Tram (RET), are generally either city-owned or privately owned, and their strategies and development are derived from the government transport solutions (Wijnand & Mulley, 2018). During Covid-19, public transport providers, in collaboration with local authorities, ensured that national Covid-19 guidelines and restrictive measures were properly enforced by their services and adequately followed by their users. Transport authorities also had the responsibility of efficiently manage national Covid-19 related funds - collected and distributed by regional authorities - to ensure the adequacy of their services under the conditions imposed by the unprecedented set of new transport policies and measures.

## 5.2. Analysis on Effectiveness of Transport Related Policies in Response to the Covid-19 Crisis

The categorization of the infectious respiratory disease 'Covid-19' as an 'A' disease under the Public Health Act (Wet Publieke Gezondheidsorg) allowed for a series of legislative executions that enabled national, regional, and local authorities to impose a series of restrictive measures to fight the dissemination of the virus (FRA, 2020). The ministry of health, welfare, and sport directed the national response to the development of the pandemic under the guidance of a wide range of experts. These national authorities collaborate with regional and local authorities to adopt and enforce the restrictive measures on both regional and local levels. The specific role tailored to each authority is explained in *Chapter 5.2.1.* The series of restrictive measures, released by national authorities on a national level, were adapted across all 354 Dutch municipalities; however, the characteristics of each application varied per municipality or region. The majority of the accessible information regarding the Netherlands ' set of measures reflected the national measure guidelines drafted by national authorities and not how regional or local authorities applied them. As a result, the measures that are taken into consideration by this study are the generic national restrictive measures drafted by the government of the Netherlands. A list of the measures with the related implications on public transport is illustrated in *Table 27*. It is important to note that there isn't a chronological order of the discussed measurers since the type and stringency of the measures constantly changed throughout the pandemic due to the national and international epidemiological progression of the virus. Instead, most of the released and implemented measures are discussed without referring to the stringency magnitude variation that each measure experienced. Once again, these measures have been applied across all Dutch municipalities; therefore, each measure's potential effect and effectiveness can be considered similar across all Dutch municipalities.

*Table 27 - National restrictive measures drafted by the Dutch government*

| Measure | Effect on transport |
|---|---|
| Closure of public locations such as museums, concert halls, cinemas, theatres, sports clubs and sports competitions | People were discouraged to travel by closing the motives of their trips. Most likely transport as a whole has declined as a consequence of this overarching measure |
| Work from home for non-essential businesses | People were discouraged to travel by allowing them to shift to a remote work setting and avoid daily traveling for work |
| Vulnerable people (elderly and people with underlying conditions) are discouraged to be in large groups and public transport | Reduced the number of vulnerable people that traveled by means of public transport |
| Restrictions to travel abroad - ban on all non-essential travels to other countries | Reduced the number of people moving within the Netherlands and the number of visitors visiting the Netherlands |
| Closure of in-person education | The shift to online learning caused a considerable reduction in daily mobility and public transport usage |
| Ban on all gatherings | This measure implied that people would greatly change their daily mobility and avoid frequent traveling to both public and private gatherings |

| | |
|---|---|
| 1.5 meter distance on all public transport | Public transport services had to be scaled down to accommodate the required safety distance - hence capacity was reduced in all public transport services |
| Restrictions on meetings indoor and outdoor (the maximum number of people allowed per group varied from 2 to 4) | Restrictions on the number of people allowed to meet both indoor and outdoor discouraged daily outdoor mobility |
| Mandatory mask in all public indoor spaces | Mask was mandatory in all means of public transport |
| Night curfew (varied from 21:00 to 22:00 throughout the pandemic) | This stern measure imposed a ban on all sort of mobility during curfew time |
| Reduction of public transport capacity and service frequency | Local and national public transport providers (e.g. NS) were forced to scale down service frequency - thus reducing number of trains, trams, bus, or metro train operating every hour - and reduced service capacity to comply with safety distance measures |

*Sources: FRA (2020); Ministry of Health, Welfare and Sport (2021)*

The majority of the restrictive measures designed to curb the spread of Covid-19 had as common objectives the enforcement of social-distancing, universal mask-wearing in all indoor public spaces, and the restraining of all non-essential public transport usage. Directly or indirectly, all these measurers affected mobility across all Dutch municipalities and altered the daily public transport ridership and private transport. The effectiveness of each mentioned measure is still subject to research and debates, and Netherlands-specific studies are still missing. However, several researchers have conducted cross-country studies to evaluate the effectiveness of government non-pharmaceuticals interventions (NPI) against Covid-19. The most effective measures resulted in being the individual or collective restrictions aimed at discouraging social contacts. NPI's like curfews, banning all types of gatherings, closure of in-person education, and individual movement restrictions were the most effective, albeit caused significant collateral damage to society, mental health, and personal and communal socio-economic stability (Haug et al., 2020; Brauner et al., 2020). The closure of businesses and public locations had a small-to-moderate effect at reducing Covid-19 transmission (Brauner et al., 2020).

On the other hand, stay-at-home orders, but most importantly, social-distancing measures regarding public transport, resulted in small effectiveness against the spread of Covid-19. Studies from a wide range of researchers found that public transport didn't have a key role behind the spread of Covid-19 (Gkiotsalitis & Cats, 2021), and that measures directly targeting public transport, such as the closure of public transport services or the reduction of service frequency, weren't effective in reducing the number of infections (Islam et al., 2020; Haug et al., 2020). Even the measure of reducing public transport capacity is debated by researchers that argue the scientific validity of the globally imposed 1.5 to 2 meter social-distancing. In fact, Bahl et al. (2020) reported that the suggested 1.5 to 2 meter social-distancing, that forces public transport providers to reduce service capacity, is based on very limited epidemiological and simulated studies. Of course, these findings do not deem public transport 'risk-less' under all conditions. As reported by Jones et al. (2020), the environmental settings of a transport service and the public compliance with face-masks obligations are crucial elements behind the idea that public transport is not a source of infections. In fact, if the environment is well ventilated and everyone wears face masks, the transmission rates remain low even under high occupancy levels (Jones et al., 2020).

Therefore, public transport might not, in truth, reflect the given public narrative, fed by premature and politicized academic reports that framed it as the massive seeder of epidemics (Harris, 2020). Instead, as Sadik-Khan & Solomonow (2020) expressed, it might be just that "fear of public transit got ahead of the evidence."

## 5.3. Policy Interventions Schemes

Both this study's results and the policy analysis conducted in *Chapter 5.2.* identify public transport as an insignificant contributor to the development of the Covid-19 pandemic, and the latter demonstrates the ineffectiveness of transport stringent measures at reducing Covid-19 transmission. This evidence shows the inadequacy of the current transport policy approach used to curb the spread of an infectious respiratory disease. Therefore, policymakers and public transport providers need to brainstorm new ways to manage public transport during a crisis. In this chapter, three alternative transport policy interventions are proposed to policymakers and public transport providers, together with their respective potential epidemiological, economic, social, and mobility implications.

### 5.3.1. Policy Intervention One: No Restrictions on Transport Services Frequency and Social-distancing

As previously described, recent policy studies have exposed the effectiveness of measures tailored to limit public transport usage during the Covid-19 pandemic (Islam et al., 2020; Haug et al., 2020) and have deemed optimal environmental settings of a transport service (ventilated environment and cleaned surfaces) and public compliance with face-masks obligations as necessary measures to guarantee the safety of passengers during a pandemic and avoid transport induced infection clusters (Jones et al., 2020). At the same time, although they confirm the benefits of general social-distancing as a mitigative strategy, some studies have also scrutinized the scientific solidity of the widely used 1.5 to 2 meters social-distancing policy that impedes public transport providers to work at full capacity and forces them to endure economic losses, pointing out that such rules are based on the over-simplistic understanding of viral transfer and that in some cases Covid-19 droplets may spread up to 8 meters (Bahl et al., 2020; Qureshi et al., 2020). One certainty in the convoluted relationship between Covid-19 and public transport is the economic imperilment triggered by the pandemic - in 2020, the Netherlands's regional public transport authorities and the national rail providers registered a deficit of respectively € 550 to 750 million and € 750 million to 1 billion (European Commission, 2020). This policy intervention scheme intends to ease the economic burner faced by public transport authorities and national public authorities while ensuring uninterrupted, reliable, and safe providing reliable and safe transport services to the public. It suggests the revocation of social-distancing guidelines and any measure or policy directed at constraining the frequency of trips made by public transport while emphasizing on the following non-pharmaceutical measures: mandatory mask-wearing in any public transport service, enhanced temperature screening, enhanced transport environment sanitization, and improved air-ventilation and air-filtering systems.

Public transport operators would have to enforce these measures at all times to ensure their effectiveness. This can be done in a twofold approach - firstly, enforcement officers could be

employed to ensure that mask-warning and personal hygiene (use of hand sanitizers) rules are obeyed; secondly, authorities could design effective informative campaigns aimed at divulging the consequences of the disease spread and the benefits of abiding by the imposed measures with the intent of increasing awareness and responsibility among public transport users. Stickers and prohibiting signs both in and out of public transport services should be placed mentioning the guidelines of safety to spur awareness (Abdullah et al., 2021). People from low educational and socio-economic backgrounds, who are more dependent on public transport (Harms, 2008), are more likely to use public transport during a health crisis, however, they are less likely to comply with the necessary precautions would require greater attention in such campaigns (Abdullah et al., 2021; Carlucci et al., 2020). Abdullah et al. (2021) proposed handing free masks and hand sanitizers in each public transport station as a potential way to urge people, especially the most diffident, to comply with the measures and avoid transport-related infections. When it comes to the other measures, public transport operators will have to assess the air-ventilation efficiency of their means of transport (bus, train, metro) and improve them if needed. The usage of HEPA filters and efficient air circulation in aircraft has proved to be highly efficient at capturing Covid-19 viral particles (European Union Aviation Safety Agency, 2020), making flying virtually safe, and the European Union Agency for Railways (ERA) has already advised the equipment of such air filtering system for railway vehicles and similar transport systems (European Union Agency for Railways, 2020). Although HEPA filters are largely used in the aviation industry, their use on terrestrial public modes of transport is less common (Kakkad et al., 2020). Therefore, public transport operators should seriously consider the adoption of HEPA filters to enhance air-cleanliness in public transport.

#### 5.3.1.1. Infection rates Implications

The effectiveness and safety of this policy intervention scheme can be guaranteed only by utter compliance with the mentioned measures. Social-distancing offered an additional layer of security, however, it damaged the economical integrity of public transport operators (Hörcher, Singh & Graham, 2021). If people abide by the mentioned measures (mask-wearing & optimal hygiene), as reported by Jones et al. (2020), most transport-related infections could be averted. Although empirical evidence shows that mask-wearing guidelines are generally followed, some studies report that not all passengers behave diligently (Dzisi & Dei, 2020). For example, the London transport authority has reported several times the tendency of a minority of transport users to violate mask-wearing guidelines, prompting the city to strengthen the presence of Metropolitan Police Service (Met) and British Transport Police (BTP) during transport operations (Mayor of London, 2020). The non-compliance of public transport users, even if in minority, can jeopardize the efficiency of transport operations and imperils the safety of its users. Therefore, it is up to the transport authorities to enforce these restrictions via the twofold approach mentioned above in collaboration with local authorities.

### 5.3.1.2. Economic Implications

The mere withdraw of social-distancing and frequency control restrictive measures will allow public transport operators to operate at full-capacity and offer complete services, potentially enabling them to preserve economic stability during a health crisis. Increasing demand would virtually bring back public transport capabilities to it's pre-Covid-19 state; however, by itself, it is not a public transport panacea for all Covid-19 related ills. Hörcher, Singh & Graham (2021) nicely elucidated that most of the economic repercussions endured by public transport operators not only stemmed from the stringency of lockdowns and work-from-home measures, but also from the operating limitations, such as social-distancing and resulting loss in capacity, imposed by the same operators, and by the wide-spreading public transport anxiety. The reopening of full-capacity public transport during a pandemic should go hand in hand with assiduous informative campaigns aimed at elucidating the safety of using mass transit. If public transport operators, in collaboration with regional/local authorities, are able to regain traveler's trust in the safety of their transport services then they will be able to dodge the economic imperils that public transport endured during Covid-19. However, if austere lockdown measures are re-deployed and if people's fear of crowded trains or bus remains, then this policy intervention scheme could have small economic benefits - people will continue to avoid mass transit and prefer to move via private transport.

In order to safely provide full-capacity public transport, authorities will have to allocate a budget to the development of the mentioned informative and preventive campaigns, to train transport employers on how to deal with crowded public transport services and enforce measures to them, and to the nation-wide improvement of transit's filtering and ventilation system. The nature of this budget can vary depending on who's responsible for these policy-related expenses. It is plausible to deduce that the establishment of this budget will follow the characteristics and cooperation of the € 1,550 millions state-aids destined to support the battered Netherland's public transport sector (Veenaman & Hirschhorn, 2021). The decision-making arrangement will be led by the Ministry of Infrastructure and Waterways - responsible for the management of public subsidies designed to support public transport - and it will involve operators (e.g., NS) and public transport representatives from province governments and from metropolitan regions (Veenaman & Hirschhorn, 2021); these authorities will be committed to develop a road-map for the refurbishment of the public transport's ventilation/filtering systems, discuss the best way to enforce measures in-and-out of transport services, and reach an agreement on the aid amount and payments mechanism.

### 5.3.1.3. Social - Mobility Implications

As described in *Chapter 2.4.*, the development of Covid-19 and the closure and service limitations suffered by the public transport sector not only had economic repercussions but also social ones, by creating a shared sense of transportation-phobia and worsening disparity related to mobility (Barbieri et al., 2021; Bird & Tsivanidis, 2020; Yaya et al., 2020). By offering reliable and continuous possibility of transport throughout a health crisis, this policy implementation scheme could diminish the impartial consequences suffered by people from a low socio-economic background and ethnic minorities, whom are largely more dependent of public transport and are less likely to own a private vehicle (Oakil et al., 2016; McLaren, 2020). In this way, these

communities will be able to maintain intact their travel behaviors during a pandemic and avoid employment repercussions related to the inability of moving because of the lack of means of transport.

The enhancement of factual information regarding the role of public transport on Covid-19 diffusion and ways to battle it efficiently, the intensification of personal and service cleanliness, the additional enforcement of mask usage, and the improvement of means of mobility's air filtering and ventilation systems are all initiatives that can also largely improve the misconceptions suffered by public transport and can help people gain their lost trust of mass transit. The same measures can improve authorities ability to warn off mask-wearing and health-guidance violators, ensuring safe and trustworthy public transport services.

### 5.3.2. Policy Intervention Two: Enhanced Hygiene, Mouth-Covering and Social-Distancing

The role of social-distancing in the public transportation sector is puzzling. As described in *Chapter 5.2*, the scientific community is divided on the effectiveness of forcing people to a defined safety-distance, which generates confusion and uncertainty amongst policy-makers and sub-sequentially public transport users. Although there is no communal opinion on social-distancing, it is important not to treat it as trivial. Asking policy-makers and public transport providers to lift social-distancing guidelines all at once can result arduous to accomplish and excessively risk-tolerant. This policy intervention scheme, just like the first one, argues against the constraining of transport service frequencies - or even more complete service closure - and advocates for mandatory mask-wearing in any public transport service, enhanced temperature screening, enhanced transport environment sanitization, and improved air-ventilation and air-filtering systems; however, contrarily to the first policy intervention scheme, it suggests keeping the social-distancing guidelines to provide another layer of control strategy to hinder the spread of Covid-19 or any future infectious respiratory disease. When it comes to the characteristics of the social-distancing guidelines that authorities should adopt, there is no universal solution to determine the optimal occupancy rate and consequential capacity cap. Hörcher, Singh & Graham (2021) provides a comprehensive literature review on the academic viewpoints on 'optimal occupancy rate', and the key insights are: the optimal occupancy rate heavily depends on the user, operator, and external costs, which are heavily influenced by Covid-19 and the economic implications of its deriving risks; optimal occupancy rate is a derived quantity: operators optimize capacity and the level of demand through price and quantity controls simultaneously, and results determine optimal vehicle load; in the absence of reliable info regarding infection probability and other input parameter's estimates, the best option is to follow the governmental guidelines and latest social-distancing regulations. Both public and private authorities will have to make a joint decision on how to assess the optimal public transport occupancy rate efficiently. This decision can either be made on a national level or on a regional/local one. However, considering that the Ministry of Infrastructure and Waterways saying weights heavily in the trajectory of policies in public transport and it is responsible for driving national transport solutions and emergency strategies (Wijnand & Mulley, 2018), the decision will have to be made centrally by the national government and regional/local authorities will have the responsibility of adopting such regulations. Enforcing social-distancing is a novel task in the public transport sectors, and operators are still

trying to figure out how to carry it out best. Efficiently imposing social-distancing could help public transport operators to dynamically balance the risk of higher degrees of proximity among passengers and the chance of shrunk demand with consequential economic losses. To facilitate the public's adherence to social-distancing, public and transport authorities can adopt the following measures retrieved from Tirachini and Cats (2020) and Hörcher, Singh & Graham (2021) works illustrated in *Table 28*.

*Table 28 - Measures to enforce social distancing in public transport*

| Measures | Description |
|---|---|
| Inflow control with queuing | Physically restricting the flow of passengers entering any public transport station, and keep the excess flow in a physical or digital queuing system |
| Advance booking and slot rationing | Travel slots will have to be booked via an online reservation system that dynamically manages the seating process. Alternative means of trips booking have to be available for people who do not have access to such electronic devices, and for the event of technical failures |
| Prioritize specific groups | Travel slots will be prioritized to specific groups, e.g. essential workers, to ensure that essential businesses and operations can run smoothly and safely |

*Source - Tirachini and Cats (2020); Hörcher, Singh & Graham (2021)*

#### 5.3.2.1. Infection Rates Implications

Although clear evidence on the exact infection rate sourced to pubic transport is currently unavailable, reducing capacity and therefore enabling social-distancing in all public transport services would surely serve as an additional safety layer, and it might help to ulteriorly diminish the risks of any potential transport derived infections. This policy intervention scheme - which provides a more cautious approach to public transport management during a health crisis - could be rigorously used in the early stages of a pandemic or during an infections-wave. It can later be dynamically adapted to the virological trends of the pandemic. In this way, the trade-off between safety and economic sustainability can be best balanced to ensure health and economic resilience in the public transport sector.

#### 5.3.2.2. Economic Implications

Imposing social-distancing and limiting capacity might benefit the safety of public transport services, however, it might continue to harm the economic stability of public transport providers that the pandemic has deeply shaken. Enforcing capacity reduction would inevitably have profound ramifications on both the national rail and local/regional public transport services; however, the degree of such implications heavily depends on the type of economic organization behind public transport services. Covid-19 has shown that public transport operators with a 'self-financing' approach - where public transport operators use their income to finance themself - suffered disproportionally the consequences of the pandemic and resulting restrictive measures, much more than their counterparts who rely on public subsidies (Hörcher, Singh & Graham, 2021). The latter model of economic responsibilities in public transport is the approach used in the Netherlands (van de Velde & Eerdmans, 2016), and it allowed the regional and local public

transport authorities to keep their head above water throughout the first part of the pandemic. However, the economic relief followed by the Covid-19 related state-aids for public transport cannot represent a long-term panacea; in the long run, the economic burner of providing economic support to different socio-economic sectors will also weigh on the economic stability of the central government. The central government and their respective regional/local authorities must collaborate to develop a joint project where universal guidelines are established to usher regional/local authorities and public transport providers across efficient subsidies management, expenses prioritization, and service adaption contingent to the development of the pandemic.

The economic implications that public transport operators and public authorities will experience due to a reduction in capacity will not be constant throughout the course of a pandemic. It is expected that public transport will feel the worst impacts during the acute stages of the pandemic when public transport avoidance is dominant and capacity is substantially limited, and the least during the lows of the pandemic when public transport usage surges as a consequence of the lifting of restrictive measures. Authorities and public transport providers' response to a crisis should be scalable and dynamic, pivoting on enhanced safety and hygiene, optimal occupancy rate, and a sound subsidies management approach.

#### 5.3.2.3. Social - Mobility Implications

Coupling the described hygiene and mouth-covering measures with social-distancing, and therefore capacity restriction, allows authorities to ensure continuity to an essential service like public transport during such uncertain times; however, restricting public transport services capacity does not come without social expenses. Any service restriction would inevitably impact, above all, people from low socio-economic backgrounds and ethnic minorities. This segment of the population's mobility would, to some degree, be restricted, potentially impacting their freedom and ability to move for work or leisure. People's mental health might also be impacted by social-distancing; studies report that changes in travel behavior as a result of social-distancing and indirect limitations on personal mobility could result in lower levels of social interaction and self-development and higher levels of mental health strains (De Vos, 2020; Brooks et al., 2020). Maintaining social-distancing for a prolonged set of time might also profoundly change people's travel behavior and attitude toward the long-term utilization of public transport. Several studies have pointed out that social-distancing could alter people's opinion on public transport and push them to avoid it altogether due to fear (De Vos, 2020). At the same time, people would be more inclined to use personal mobility, such as cars, questioning the future outlook on problems such as traffic jams, noise, and pollution (Elks, 2021). Authorities should consider these potential implications when evaluating the possibility of maintaining social-distancing in their public transport services.

### 5.3.3. Policy Intervention Three: Mitigate Capacity losses by Means of Integrated Door-to-Door Transport Ecosystems

Like the previous policy interventions, policy intervention three pivots on the enforcement of mouth-covering, enhanced temperature screening, enhanced transport environment sanitization, and improved air ventilation and air-filtering systems - these fundamental measures are at the base of any societal attempt at fighting the dissemination of the virus and related socio-economic implications. Following the reasoning elucidated in the second policy intervention, this policy intervention scheme also implies the necessity of adopting social-distancing as an additional safety layer to augment the health-security of public transport systems and their riders. What differs in this policy intervention scheme is the mitigative approach used to diminish the socio-economic repercussions of social-distancing and restrained service capacity. It is clear that constraining capacity through enforced social-distancing during a health crisis can severely imperil the economic stability of public transport providers, which are then forced to rely on finite state-aids to avoid an economic abyss (Hörcher, Singh & Graham, 2021; Veenaman & Hirschhorn, 2021); at the same time, it can damage people's well-beings (Brooks et al., 2020).

In order to compensate for the loss of capacity caused by social-distancing, national authorities and public transport providers should develop strategies on how to adapt both service and capacity to demand quickly. One approach that can be used for this purpose is the integration of different sections of mass transit. As described by the German board of academic advisers to the federal minister of transport and digital infrastructure (2020), to guarantee service in the event of a shortage of resources (like service capacity) or personnel as a consequence of restricted capacity, it could be beneficial the coupling of public transport with other transport providers, like private bus operators (e.g., Flixbus) or shared mobility providers (e.g., Greenwheels or Felix) to tap additional potential for a short-term capacity expansion. Integrating public transport to shared mobility services is not a new concept, as it is the fulcrum of the Mobility as a Service (MAAS) project; therefore, having access to such digital service could help mitigate the transport challenges for the future health crisis. It is also important to note that the degree of flexibility deriving from shared mobility complementary to public transport could help to prevent the inevitable unfair shift to private transport that deepened ethnic disparity during Covid-19 (Lozzi et al., 2020) and worsened congestions and air pollution (Sadik-Khan & Solomonow, 2020).

Another tool that public transport providers and municipalities could use to ensure transport resilience during a health crisis is enhanced information for transport riders. Providing immediate live information regarding a service capacity could become a preventive method to discourage crowded mass transit naturally. Nederlandse Spoorwegen (NS), Rotterdamse Elektrische Tram (RET), and other Dutch public transport providers have designed a crowd indicator - visible on the online app of the provider - that reports the expected live crowds during a trip by bus, tram, metro, or trains, allowing people to avoid or postpone trips if reluctant to share it with large crowds. Expanding this digital service and integrating it into a public bus, train, metro, tram station could serve as an effective self-management tool to avoid passengers overload, safeguard the 1.5 to 2 meters rule, and allow the practice of social-distancing measures.

#### 5.3.3.1. Infection Rates Implications

Using continuous mouth-covering, enhanced hygiene, temperature checking, and ventilation measures, and social-distancing would surely enhance the prevention of public transport induced infections; however, it is yet not clear what are the epidemiological consequences of enlarging and integrating public transport with other means of transport (e.g. shared mobility or private bus operators). Recent studies have shown that alternative means of transport, such as shared mobility, share similar setbacks experienced by public transport services - the number of trips made by means of shared mobility dropped rapidly with the arrival of Covid-19, primarily due to the perceived fear of associated with shared mobility (Andersson et al., 2020), and to the challenge to meet safety requirements in shared mobility industry (Garaus & Garaus, 2021). Shared mobility providers have already responded to such challenges by enhancing cleaning measures and improving their communications with worried riders (ShareNow, 2020a); however, such interventions differ across the industry and are enforced differently, leaving confusion among potential users. One way to convince people on the safety of using shared mobility, as an integrated means of transport to public transport, is by extending enhanced hygiene and mouth-wearing to all means of transport beyond mere public transport, creating a sense of policy-continuity across all the transport dowels that compose this integrated systems of public transport.

#### 5.3.3.2. Economic Implications

This policy intervention scheme seeks to provide a solution to the economic losses caused by social-distancing by expanding the type of means of transport that public transport riders can use. In theory, the economic burner of lost ridership in public transport can be mitigated by providing an alternative way to move around to these lost potential riders. However, the effectiveness of such a transport ecosystem in mitigating the described economic losses heavily depends on the quality of this system's development, robustness, and safety. The pre-pandemic development status of integrated door-to-door mobility services like Mobility as a Service (MaaS) greatly varies by country. The Netherlands, in specific, although they are at the forefront of developing integrated transport services like MaaS, were not ready to use this service during the pandemic. However, the pandemic itself ignited conversations around the importance of such mobility service in an unprecedented crisis like the Covid-19 pandemic, stimulating the stipulation of a contract that foresees the development of a countrywide intelligent Mobility as a Service (MaaS) platform by Siemens mobility (Siemens Mobility GmbH, 2021). *Note: this study will not elaborate on how authorities, public transport providers, and providers of other means of transport (e.g., shared mobility) should handle the governance and revenues management of such transport ecosystem; for further details on such information, it is suggested to consult the United Nations Economic Commission for Europe (UNECE) Mobility as a Service report (2020).*

Although intelligent integrated door-to-door mobility services like MaaS can help mitigate the economic implications of a nationwide health crisis, its development can be costly. Some of the costs that authorities would have to consider before developing such mobility ecosystems concern the development of an intelligent platform and necessary infrastructure changes. In addition, in the event of a health crisis, all the means of mobility will have to be adapted to the hygiene measures consistently, which can be a costly policy intervention.

#### 5.3.3.3. Social - Mobility Implications

Allowing people to smartly use different means of transport, including non-public transport services, for their door-to-door mobility would unlock unprecedented potentials for human mobility. It would allow personal mobility during high peaks of demand in the capacity-constrained public transport, but it will also give people the option of tailoring their mobility to their personal needs and preference of means of transport. Additionally, such integrated transport services might discourage the usage and purchase of polluting private means of transport (e.g., cars) and are shown to provide significant environmental and social benefits (Streeting & Brown, 2019; Storme et al., 2021). Reducing car ownership and allowing equitable access to a vast network of means of transport might ulteriorly diminish the transport induced disparity witnessed throughout the Covid-19 pandemic, where low socio-economic individuals and ethnic minorities were less likely to practice social-distancing due to their inability of switching to private means of transport (Bird & Tsivanidis, 2020; Yaya et al., 2020) and they were the ones that felt more at risk because of the public anxiety associated with public transport (Abdullah et al., 2020). However, it is essential to mention that this integrated door-to-door mobility approach implies that only people with stable access to a mobile phone and internet connection can access it. Although this represents a majority, people from a low socio-economic background still experience faulty internet access, and therefore might not be able to fully use the advantages that this novel mobility service entails. Authorities should ensure that most of their citizens have stable access to the internet and affordable phones, which can be done by providing targeted incentives. Lastly, this policy intervention scheme creates the opportunity to foster digital interactions and enhanced social-distancing. In fact, wide usage of a service like MaaS could vastly reduce physical ticketing purchases and related physical queues, enhancing online ticket purchases and queues. This online shift in transport can ease people's ability to practice social-distancing during a health crisis like Covid-19.

# 6. Conclusions

This chapter wrap-ups and reflects on the work accomplished by this study. It reflects on the literature gap and the author's objectives that motivated the development of this study. It then summarizes the study design and the method used for the analysis. This is followed by a reflection of the main findings with related policy implications. Lastly, this chapter discusses the recommendations tailored for policymakers and the ones destined for future research.

## 6.1. Gap in Existing Literature

There is a growing body of research that seeks to untangle our understanding of the dominant ethnic disparity drivers at the source of disadvantageous health conditions experienced by people from an ethnic background. For years, researchers have indicated that precarious socio-economic status, lack of education, inadequate living environments, and unsafe working conditions are responsible for producing inequitable health outcomes (National Association of County and City Health Officials, 2002; Wang & Geng, 2019). Beyond these social and economic factors, researchers have also pointed out the role of transportation policies and related differences in travel behavior in health disparities (Sánchez et al., 2003). The unfairness in health between ethnic groups deepened and crystallized with the abrupt arrival of Covid-19, which has been shown to disproportionally impact people from an ethnic background (Schmitt-Grohé, Teoh & Uribe, 2020). The academic response to this worldwide health crisis was to swiftly understand the critical social and economic drivers behind the proliferation of the virus, with early studies pointing out environmental, pre-existing health, and socio-economic conditions. When it comes to the role of transportation, researchers have yielded contrasting results. Some of them blamed public transport for Covid-19 outbreaks, urging policymakers to bring it to a stall (McLaren, 2020); others have cleared public transport from any accusation, explaining that, if proper hygiene and restrictive measures were adopted, it would not represent an epidemiological risk to society (Islam et al., 2020; Haug et al., 2020). The incongruence in recent literature, the absence of Netherlands-specific studies that investigate the role of disparity in travel behavior in the disproportionate impact of Covid-19 suffered by ethnic minorities, and the moral obligation at contributing to the scientific community at unveiling the fundamental sources of ethnic disparity to attempt to outline a remedy to it, have encouraged the development of this study.

The reason behind focusing on the Netherlands for this study is twofold. Firstly, although there is a lack of ethnic-specific data, the Netherlands is one of the few countries in Europe that offers access to a vast and recent quantity of data on people's socio-economic status, living conditions, travel behavior, and Covid-19 records. Secondly, due to its multiethnic nature, the Netherlands witnessed the impact of ethnic health disparity during the pandemic, and therefore it would have been a relevant subject for this study. This research aims to firstly either confirm or not the disproportionate health implications - identified in the number of infections, deaths, and hospital admissions - suffered by ethnic minorities compared to their Dutch-native counterpart, and then elucidate on the role of disparity in travel behavior in the overrepresentation of ethnic minorities among Covid-19 victims. The objectives of this study can be merged in a research question formulated in the following way:

To what extend disparity in travel behavior is influencing the disproportionate incidence of Covid-19 infections and deaths among ethnic minorities? And how can policy-makers and public transport providers best adapt public transport to future discriminatory health crises?

Furthermore, this study's results might signal fundamental notions that could have significant implications on the governance of public transport systems and the safety of its riders. Therefore, it becomes essential to understand what policy implications this study's results might have and the steps that policymakers can make to address any related issue. These consequential dilemmas result in an additional research objective to provide detailed insights on the policy implications of this study and develop policy interventions to enhance resilience and fairness in the public transport system during a nationwide health crisis. This represents an extension to the original aim of this study, which is captured by the second part of the main research question written above.

## 6.2. Study Design

The relationship between ethnicity and Covid-19 and the role of travel behavior as a mediator between the two can not be analyzed in a simple manner. The relationship between ethnicity and Covid-19 is multifaceted and highly complexed - besides not being the only potential intermediator between ethnicity and Covid-19 records and travel behavior - is also intrinsically influenced by socio-economic conditions. To reveal the convoluted and interrelated influence between ethnicity, socio-economic variables, travel behavior, and Covid-19, the statistical method Structural Equation Modeling (SEM) is used.

Structural equation modeling, one of the most popular methodologies in the quantitative social sciences (Kaplan, 2001), is a flexible linear-in-parameters multivariate statistical modeling technique whose earliest usage in the travel behavior domain dates back to 1980 and now represents a key tool in the field (Golob, 2011). An SEM model can analyze a researcher's theoretical model, pivoted on literature and sound hypothesis, and capture the causal influences of the indicated exogenous variables on the endogenous ones and the casual influences among exogenous variables (Golob, 2011).

To perform this nationwide multivariate analysis, data on the ethnic composition, socio-economic conditions, travel modal split, and Covid-19 implication rates of all 353 Dutch municipalities is required. This comprehensive dataset will be fetched from Waarstaatjegemeente (VNG), a publicly available platform that bundles, processes, and presents data from and about municipalities for everyone (Waarstaatjegemeente, 2019). These 'dashboards' provide access to an extensive list of variables ranging from Covid-19 records, demographic, work & income to mobility for all the 353 Dutch municipalities in all important policy areas. The databases come from various sources such as municipalities, citizens and business polls, Statistics Netherlands, COELO, DUO, GGD, Kadaster, the Chamber of Commerce, the Electoral Council, NOC * NSF, Logius, RIVM, and veiligheid.nl; and its update frequency depends on the publication frequency for each data source, which can be either continuously, daily, or annually (Waarstaatjegemeente, 2019). The most recent dataset for each included variable is used to ensure that the most current social and behavioral conditions can be captured. This, in turn, leads to a chronological inconstancy between variables, representing a limitation to this study.

For this study, two models have been designed, including the same socio-economic, health, spatial, travel behavior, and Covid-19 variables; however, they differed in the ethnic background variables included. The first model sought to merely analyze the differences in relationships between Dutch natives and all people with an immigrant background. The second offered a disaggregated view of major ethnic minority groups in the Netherlands. *Figure 5* from *Chapter 2.12*. illustrates the conceptual model that functioned as the foundation for both models. It represents the construct of relationships that will be analyzed and tested in this study. The purpose behind this dual approach was to firstly compare the direct and indirect relationship between the Dutch natives and people with an immigrant background as a whole while analyzing the intermediating role of travel behavior in this relationship; secondly, to understand if this type of relationship varied within the 'people with an immigrant background' ethnic group and to comprehend which specific ethnic minority suffered the most from Covid-19 related implications. At the same time, including all ethnic groups in one unique model would have resulted in strong multicollinearity between them, jeopardizing the reliability of results.

## 6.3. Main Findings

Results from both models confirmed the notion that, in the Netherlands, **ethnic minorities are more likely to suffer from Covid-19 infections and related hospital admissions but are not more at risk of death compared to their Dutch counterparts**. At the same time, in both models, travel behavior - identified as the modal split between train, public transport, car, biking, and walking - was found to be an insignificant predictor of Covid-19 infections, hospital admissions, and deaths with the unique exception of walking and car usage. Instead, 'low education level', 'persons per household', and 'population density' result to be strong positive predictors of Covid-19 related implications. This suggested that, unlike initial hypothesis and countercurrent to the findings from most American-specific transport literature, **public transport does not represent a key driver behind the development of Covid-19 infections, death, and hospital admissions; instead, other socio-economic variables and, most notably, spatial variables could be considered significant drivers of the Covid-19 pandemic**. Both models also diminish the intermediating role of public transport in the relationship between ethnic background and Covid-19 records. More specifically, results demonstrate that **the registered positive relationship between ethnic minority groups and Covid-19 variables can be sourced to their direct relationships, and therefore travel behavior - but also the other intermediating variables such as socio-economic ones - does not appear to mediate the relationship between ethnic minority groups and Covid-19 related implications.**

What the second model offers that the first does not is a deeper insight into how Covid-19 disproportionally impacts ethnic minorities. **Results from this model demonstrate that the registered disparity in healthcare outcomes varies between ethnic minority groups**. The 'Morocco' ethnic minority group appears to experience higher Covid-19 infections and related hospital admissions but no deaths. The 'Turkey' ethnic minority group is the only other ethnic minority that registered a positive relationship with Covid-19 infections, however much weaker. On the other hand, the ethnic group 'western immigrant' results to be a negative predictor of Covid-19 infections; however, the relationship becomes positive with Covid-19 hospital admissions and Covid-19 deaths. This might indicate that western immigrants experience fewer rates of Covid-19 infections; however, once infected, they experience more serious implications and higher death rates. The last ethnic minority included in this study, 'Other non-western

immigrant', appears to be the least affected by Covid-19, registering a significant negative relationship with 'Covid-19 hospital admissions' and 'Covid-19 deaths' but insignificant with 'Covid-19 infections'. The motives behind this healthcare outcome disparity among ethnic minority groups are hard to conceptualize, mostly because a majority of these relationships can be derived from the direct portion of the relationship between ethnic minority groups and Covid-19 variables. The only exception is for the relationship between 'western immigrant' and Covid-19 infections, whose relationship is mostly derived from their indirect relationship, indicating the significant role of some mediating variables such as spatial variables.

The results yielded by the SEM analysis are in no way definitive proof of the role that public transport plays in healthcare outcome disparity between ethnic groups during a health crisis; instead, they shall be taken as indicators of the nature of these variable's relationship and as inputs for future studies and transport policy development.

## 6.4. Policy Implications

Results that confirm the notion that ethnic minorities are more likely to suffer from Covid-19 related infections and hospital admissions than their Dutch counterparts and that this ethnic disparity is even more complex among ethnic minorities should be of pivotal importance for policymakers and central authorities to delineate mitigative policy interventions. Unfortunately, the nature of the findings - the registered positive relationship between ethnic minority groups and Covid-19 variables can be sourced to their direct relationships, and therefore mediating variables like travel behavior or socio-economic variables do not seem to have any mediating role in this relationship - does not allow to outline well-grounded policy recommendations on how to prevent health disparity between ethnic groups during a pandemic; however, such findings signal an urgent societal issue that is worth to investigate further.

However, the other facet of this study's results offers a point of reflection on the validity of current measures applied to the public transport sector. Both models found that travel behavior based on public transport did not represent a significant contributor, therefore a significant mediator, to the development of the pandemic; while, against what was initially thought, car usage (for deaths, and hospital admissions) and walking (for infections, deaths, and hospital admissions) to some degree did. These interesting findings portray public transport in a less guilty role during the pandemic, which contrasts the general opinion described in *Chapter 2,* and can be used to outline recommendations aimed at reassessing the way it is managed during the pandemic. Firstly, results triggered a detailed study of current transport policy measures implemented by the Dutch government throughout the pandemic, intending to evaluate their effectiveness and implications on the service and its riders. Transport policy literature unveiled a contrasting scenario to what elucidated by previously consulted literature, primarily based on former infections viruses like Influenza H1N1, that shared the narrative that depicted mass transit as a super epidemiological spreader (Muley et al., 2020; Charu et al., 2017; Kim et al., 2010; Brownstein et al., 2006; Merler & Ajelli, 2010; Khan et al., 2009). Most Dutch restrictive measures were issued centrally and enforced by regional and local authorities and reflected series of measures adopted elsewhere; among these measures, there was the obligation to wear the masks in all public indoor spaces, limitations on public transport services, closure of in-person education and all non-essential businesses, and more. All these measures, listed in *Table 27,* have had a degree of impact on public transport operations and organization by reducing directly or indirectly people's daily mobility and by generating fear of the conventionally busy mass transit services. Recent transport policy research showed that in several cities, such as Paris, none of the identified Covid-19 clusters

originated from mass transit (Berrond, 2020), and that public transport did not have a key role in the spread of Covid-19 (Gkiotsalitis & Cats, 2021). Other policy studies have shown that measures directly targeting public transport were ineffective in reducing the number of infections (Islam et al., 2020; Haug et al., 2020).

Results from this study and from the policy analysis, conducted in *Chapter 5.2* that questioned the effectiveness of public transport-related stringent measures, can be used as hard evidence of the ineffectiveness of some transport stringent measures at reducing Covid-19 transmission, especially the ones aimed at limiting service frequency or bringing it to a complete stall. In the wake of these findings, this study proposes three alternative transport policy interventions schemes to policymakers and public transport providers, including a brief description of their potential epidemiological, economic, social, and mobility implications. All the following policy interventions are founded on the shared idea that restricting service frequency or enforcing service closure are not effective measurers, and therefore they will not be part of any policy recommendation scheme.

The **first policy intervention scheme** represents a more risk-tolerant approach to managing public transport during the pandemic. It is based on the scientific notion that mask-wearing in any public transport service, enhanced temperature screening, enhanced transport environment sanitization, and improved air ventilation and air-filtering systems are the best preventive tools to fight the spread of the virus. At the same time, it proposes the lift of social-distancing measures to alleviate the economic suffering of public transport providers and stimulate the public to place their trust back in public transport. This approach could have positive socio-economic impacts; however, it could also pose an epidemiological risk if measures are not carefully obeyed and public transport services go back to being overcrowded. The **second policy intervention scheme**, just like the first one, argues against the constraining of transport service frequencies and advocates for the same fundamental safety measures. However, it proposes also to maintain adaptive social-distancing in every public transport service to provide another layer of safety against the transmissions of a virus. This approach can have socio-economic ramifications. To begin, public-transport providers might continue to rely on state aids, weighting on the national economy and putting their economic stability at risk. At the same time, keeping social-distancing for a prolonged period could impact people's well-being and alter travel behavior in the long term. The **third policy intervention scheme** proposes an innovative approach, yet economically demanding, to best handle public transport during a pandemic. Besides maintaining mandatory fundamental measures (mouth-covering, enhanced hygiene, temperature screening, and air ventilation) and social-distancing, it proposes a mitigative approach to diminish the socio-economic repercussions of social-distancing and restrained service capacity. It consists of coupling public transport with other transport providers, like private bus operators (e.g., Flixbus) or shared mobility providers (e.g., Greenwheels or Felix) to tap the additional potential for a short-term capacity expansion. This approach resonates with the Mobility as a Service concept. Depending on its degree of complexity, this approach can be economically daunting; however, it might have the potential to enhance and tailor human mobility like never before. At the same time, it can help travelers practice social-distancing even during peak hours and excessive transport demand.

## 6.5. Recommendations for Policy Interventions

As described in *Chapter 5.2.2.*, imposing measures designed to restrict mass transit with the final objective of reducing the proliferation of a respiratory virus does not represent an efficient approach (Islam et al., 2020), and this study goes to confirm this narrative. Therefore, policymakers and researchers should interrogate themself on how to best adapt public transport to such a daunting societal challenge. Asking public authorities and public transport providers to ignore a health peril like Covid-19 is inconceivable. These authorities have the moral imperative of adapting every socio-economic layer of a country to the crisis and design responses that would help them to mitigate it best. Researchers have already demonstrated that by ensuring a clean and ventilated environment and by pressing on people's civic sense to respect behavioral guidelines, like universal mask-wearing, public transport could function at standard capacity without compromising the health of its passengers (Jones et al., 2020). Therefore, in the wake of this study's results and on literature findings demonstrating the inefficiency of restraining measures tailored to public transport, policymakers, and public authorities are advised not to impose stringent measures on public transport, such as capacity reduction, service limitations, or complete service closure. Instead, they are advised to adapt public transport services to the relative crisis diligently, focusing on mitigating the safety and socio-economic impact that derives from it. To begin, authorities can base their mitigative strategy on one of the three suggested policy intervention schemes (*Chapter 5.3*). The establishment and selection of a policy intervention scheme depends on few factors:

- **The epidemiological status:** Authorities should avert implementing more risk-tolerant strategies like the second policy intervention scheme if the pandemic is in full force. Depending on current and forecasted development of infection, deaths, and hospital admissions rates, authorities from the multi-level organizational of Dutch public transport (or any other informal decision-making arrangement like the national public transport council) can decide to adopt more stringent variations of the proposed schemes or not (for example decking to either use or not use social-distancing) and adapt public transport services to them.

- **The economic condition of central authorities and public transport providers:** As broadly described, both the development of a pandemic and the measures adopted to curb it can have profound economic implications. The current pandemic has shown the economic fragility of the Netherlands ' public transport services that had to rely on public subsidies to survive. However, feeding state-aids to a bleeding transport service might not necessarily represent a long-term strategy to overcome this problem. The Netherlands ' authorities will have to evaluate their public transport governance during a pandemic also based on their economic stability and on the public transport operators' one. Some of the proposed policy intervention schemes, such as the first one, offer a remedy to mitigate the economic implications of the pandemic and allow public transport operators to avoid deep economic losses.

- **The governance of public transport services:** The allocation of decision-making power and responsibilities within the public transport domain can vary between countries, ranging from centralized decision-making power to decentralized one that gives power to the singular regional/local authorities or to the public transport providers themself. The type of public transport governance has great repercussions on how the whole sector faces and deals with socio-economic and health challenges. Covid-19 has shown that public transport operators with a 'self-financing' approach - where public transport operators use their income to finance themself - suffered disproportionally the consequences of the pandemic and resulting restrictive measures, much more than their counterparts who relied on public subsidies to

survive (Hörcher, Singh & Graham, 2021). The latter model of economic responsibilities in public transport is the approach used in the Netherlands (van de Velde & Eerdmans, 2016), and it allowed the regional and local public transport authorities to keep their head above water throughout the first part of the pandemic. Therefore, public transport sectors in which public transport providers operate under the guidance and assistance of central authorities, like in the Netherlands, might be able to afford more dynamic and costly policy interventions, such as the sector-wide air ventilation and air-filtration improvement or the development of occasional or persistent integrated door-to-door transport ecosystems. On the other hand, 'self-financing' public transport operators and authorities would have to manage the economic struggle on their own and develop tailored policy intervention schemes adapted to their economic availability.

## 6.6. Recommendations for Future Studies

Although this study shares the notion that public transport had not a significant role in the overrepresentation of Covid-19 infections and fatalities among ethnic minorities, it left a knowledge gap unaddressed:

*If it is not a disparity in travel behavior, what causes this healthcare outcome disparity between ethnic minorities and their Dutch-native counterpart?*

Findings from this study shall be used as intellectual inputs to deepen our understanding of the relationship and causality between ethnicity, socio-economic background, travel behavior, and disparity in healthcare outcomes during a pandemic. One element that constituted a limitation for this study's ability to catch the multidimensional relationship between these domains is the need for scientific parsimony to yield reliable results. However, the relationship between different societal domains is far from simplistic. Reality is dominated by the interdependency and interconnection of numerous elements, whose relationship is inherently influenced by environmental, societal, or political settings specific to each country or region. As a result, to thoroughly understand the role of travel behavior in Covid-19 related health disparity in the Netherlands, it is advisable to conduct Netherlands-specific studies on this matter while attempting to recreating with fidelity the intricate relationship between the mentioned domains even at the cost of parsimony. It is also suggested to re-perform the study conducted in this paper once transport modal split data collected during the Covid-19 pandemic is made available to the public.

As of now, there is sufficient scientific evidence to move the scrutinizing scientific lens towards other potential catalyzers of the disadvantageous implications experienced by ethnic minorities during the Covid-19 pandemic. This study advises future scientific researchers to study the following conditions: A deeper look into the role of spatial and environmental conditions on the higher incidence of Covid-19 infections among ethnic minorities and the relative role of disparity in employment background.

The first recommendation is a consequence of the findings illustrated in *Chapter 4*, which pointed out the decisive role that spatial variables (persons per household and population density) played as predictors of Covid-19 infections, hospital admissions, and deaths. The same results highlighted the opposing significant relationship between spatial variables (persons per household and population density) and ethnic background, indicating that there is a strong disparity in where Netherland's inhabitants live - results showed that ethnic minorities tend to live in densely populated areas where Covid-19 has shown to proliferate more - and in how populated their

household is - with great surprise this study's findings reported that Dutch natives tend to live in much more populated households compared to their ethnic minority counterpart. It could be beneficial to deepen our understanding of the role of these living conditions on Covid-19 unfair impact.

The latter recommendation is something that has not been included and analyzed by this study; however, it has been deemed as a potential key driver by literature (Papageorge et al., 2020; Stafford, Hoyer & Morrison, 2020) and by news stories (van de Klundert & Start, 2020). Future research should attempt to englobe differences in employment background, such as between white collars and blue collars, in their studies on what causes ethnic disparity, and analyze how this difference influenced the healthcare outcomes of different ethnic groups.

# 7. Reflections

This chapter reflects on the research goals that guided the development of this thesis and on its findings. It later discusses the scientific contribution and the societal and policy implications of this study. Lastly, it reflects on the limitations of this study.

## 7.1. Reflections on Research Goals and Findings

The research goals formulated at the beginning of this study have mutated with the author's understanding of the complexity of this topic and the type of results yielded by the analysis. Before elaborating on this premiss, it is important to mention that this study developed simultaneously to the Covid-19 pandemic. Although early findings signaled the occurrence of ethnic disparity in healthcare outcomes related to the pandemic (most coming from the United States ), there were a limited number of studies that tried to unveil the main drivers behind this issue. Most studies focused on the effect of pre-existing health conditions, low socio-economic conditions, precarious living standards, and pollution on the overrepresentation of Covid-19 infections among ethnic minorities, with only a few American-based studies attempting to analyze the role of travel behavior. Months after the beginning of this study, the collective scientific understanding of the virus and its underlying main drivers evolved, and researchers were able to not only further understand the role of public transport and travel behavior on the pandemic but also assess the effectiveness of policy interventions aimed at constraining mobility and therefore allegedly curbing the spread of the virus technically. Consequently, this study initially began with the sole interest of understanding if, just like in studies conducted in the United States, public transport played a significant role in the ethnic health disparity witnessed in the Netherlands. However, thanks to access to new literature, it later evolved into a twofold study. Firstly, as mentioned, it sought to understand whether public transport usage, common among ethnic minorities, played a role in the registered ethnic health disparity. Secondly, after analyzing its findings and consulting new literature on this matter, it aimed to diligently inform authorities on how best to manage public transport systems during a health crisis to avoid socio-economic implications derived by the pandemic and by unprecedented stringent measures adopted by policymakers.

Once results from the SEM study were analyzed, there was little clarity on how they could be best used to provide added value to policymakers and public transport providers. To begin, researchers' opinions on the role of public transport and related policy interventions on the pandemic's socio-economic and health implications widely differed in the field. One side deemed public transport a primary spreading source and described stringent policy interventions (e.g., reduced service frequency) as necessary. On the other side, researchers acquitted it from such faults, specifying that findings showed public transport did not majorly contribute to the spread of the virus and that excessively restrictive measures could be efficiently replaced with enhanced hygiene, air filtering, and temperature check measures. In this conflicting environment of opinions, it was difficult to propose a specific set of recommendations for fear of ending up being one-sided or risk-tolerant. The first suggestion was to use this study's findings, information gathered from literature review, and policy analysis on the current transport-related restrictive measures to outline three policy intervention constructs that authorities and public transport providers could use to mitigate the witnessed ethnic health disparity and the economic implications brought by the pandemic. Furthermore, throughout the policy interventions scheme's drafting, it appeared necessary to elaborate on the implications coupled to each scheme to provide further guidance to

policymakers. Under the guidance of Prof. Veeneman, the author decided to focus on epidemiological, economic, and societal/mobility implications to provide an overarching comprehension of what can be expected from each policy intervention.

## 7.2. Scientific Contribution

This study intended to fill a knowledge gap at the base of our faulty understanding of the relationship between ethnicity, travel behavior, how a virus spreads through society, and why it seems to do it fasters across a particular segment of it. It tried to do it holistically, not only by analyzing the direct and indirect relationship between ethnicity, travel behavior, and Covid-19 but also by including external variables that would have affected them and the relationships between them. Due to the overarching nature of this study, its scientific contributions are many, and they all offer insightful inputs for the scientific community and policymakers. All the scientific contributions that will be described below could be taken as starting points for future studies. The main contributions are the following:

- Alongside analyzing the ethnic health disparity and the role of travel behavior in it and on the general spread of Covid-19, this study also provides an in-depth analysis of the multifaceted differences between ethnic groups in the Netherlands; and it does it in two ways: firstly, it provides an exhaustive literature review on major scientific works on the socio-economic, living, health, and travel behavior differences between ethnic groups based both on Netherlands-specific studies and foreign ones. The author then tries to turn every found relationship and causation between the mentioned domains into a theoretical model that first and foremost illustrates the complexity of ethnic disparity and depicts the factors that could influence the relationship between ethnicity and Covid-19, and that will later be used as the conceptual guideline for the analytical part of the study. Secondly, it provides empirical evidence on the type and magnitude of relationships between ethnicity and socio-economic, spatial, health, and travel behavior. These results evaluate each relationship and compare it with other ethnic groups, measuring the level of disparity between ethnic groups. Details on such findings can be found in *Chapters 4.3.1. & 4.4.1.*

- Most of the studies that revealed the disproportionated health burden experienced by ethnic minorities during the Covid-19 pandemic are based in the United States and the United Kingdom, while only a handful is based in the Netherlands. This study further confirms the health disparity that ethnic minorities experience in the Netherlands; furthermore, it also reveals how health care outcome disparity differs within the ethnic minorities segment of the population. To the best of the author's knowledge, this is something that no studies have attempted to analyze in the Netherlands.

- To the best of the author's knowledge, this study is the first attempt to understand the mitigative role of travel behavior between ethnicity and Covid-19 records in the Netherlands. Most of the consulted Dutch-based literature merely reflects the disproportionate incidence of Covid-19 infections and deaths among ethnic minorities compared to their Dutch counterparts. This study is also the first Netherlands-specific attempt to evaluate the relative mitigative role of travel behavior compared to socio-economic, spatial, and health variables, with the intent of finding the significant drivers behind Covid-19. This study seeks to press the scientific community in the Netherlands to explore such an untapped topic of extreme relevance, considering the dramatic societal impact that the Covid-19 pandemic had.

- A growing body of research attempts to further our understanding of the nature of the relationship between different means of transport and the spread of a highly infectious respiratory disease. This field of research is merely divided into two parts. The first seeks to understand the implications of the pandemic of our travel behavior, and although the majority of studies are either based in the United States, China, or the United Kingdom, few are also based in the Netherlands (de Haas, Faber & Hamersma, 2020; de Haas et al., 2020). The other part attempts to analyze the inverse relationship, where travel behavior affects the evolution of the pandemic. As mentioned earlier, there are contrasting opinions on this effect; however, to the best of the author's knowledge, no studies have attempted to analyze it within the Dutch borders. Therefore, this study might be one of the first Netherlands-specific studies that attempt to clarify the role of different travel behaviors - more specifically, public transport usage - in the evolvement of Covid-19 infections, deaths, and hospital admission rates.

- This study used an extensive literature review, policy analysis, and results from the SEM analysis to provide informed and detailed policy interventions schemes to the Dutch public transport decision-making cooperation, which includes national authorities, regional/locals, and public transport providers. It contributes to the swelling body of research that uses an improving scientific understanding of the relationship between public transport and the pandemic to guide policymakers and public transport providers to adapt transport services to the constantly evolving pandemic diligently. It does it by considering the public transport governance profile of the Netherlands and the possible multifaceted implications that each suggestion might have on it.

## 7.3. Limitations of this Study

Throughout this study, several limitations have been described, while others have not yet been discussed. This chapter provides an overview of the limitations that could have conditioned the quality and interpretation of results and the deepening of initial aims. Limitations are structured in relation to elements of this study in which they have been registered.

### 7.3.1. Dataset Limitations

The year of publication of each used dataset varies dependently on the genre of each dataset. The majority of the ethnic-related and demographic variables have been fetched from datasets dating back to 2019 and 2020. However, in the case of health and travel behavior variables, the latest available dataset is the 2017 - with some exceptions in the health domain - which fails to provide a recent view on Dutch travel behavior and health conditions. The lack of up-to-date data, especially for the travel modal split in the Netherlands during the Covid-19 pandemics, represents a significant limitation for this study. Although the difference in the modal split between pre and during Covid-19 levels is subject of debate - some report a quite similar modal split (Medimorec et al., 2020) while others a drastic difference (Abdullah et al., 2020) - it is important to not forget that the inability to use recent travel modal split data hinders the faculty of analyzing travel behavior changes during a health crisis, which is known to undergo alteration because of the socio-economic implications of such calamities. Instead, it only offers travel data from a period free of any major crisis. Different mobility datasets that showed the effect of the pandemic on the travel behavior of the Netherlands residents could have given different results on the role of 'travel behavior' as a mediating variable; however, this will remain speculation.

### 7.3.2. The Intrinsic Complexity of Measuring Socio-Economic and Health Conditions

Implying that socio-economic and health conditions of municipality's ethnic groups can be measured through few generic indicators represents a significant limitation. Socio-economic status does not depend solely on the level of education, disposable income, and unemployment rate. However, it depends on a broader and detailed range of institutional, cultural, and social factors that are ulteriorly all related and affected by each other. Therefore, the identifications of such conditions are highly convoluted. This study attempts to outline a general idea of the socio-economic and health characteristics based on the availability and reliability of the accessible variables and datasets while still trying to maintain parsimony for the statistical analysis, which is usually a favorable procedure if backed up by rationality (Sivo & Willson, 1998). Obscuring the impact of many other variables in this study surely represents a limitation; however, it can also benefit the result's reliability and comprehension.

### 7.3.3. Veiled Data Collection Process

This complex multivariate study required the usage of several different datasets publicized from different sources. Although the majority of the datasets were collected from the public platform Waarstaatjegemeente (VNG), they sourced from various publishers such as municipalities, Statistics Netherlands (CBS), COELO, DUO, GGD, Kadaster, the Chamber of Commerce, the Electoral Council, NOC * NSF, Logius, RIVM, and veiligheid.nl. The dashboard Waarstaatjegemeente (VNG) does not provide much information on the nature of the used datasets and each collection process. The quality and format of datasets can vary across different sources, and an unclear understanding of the details of each dataset can represent a limitation to the quality and truthfulness of related statistical results.

### 7.3.4. Limitations inherent to the Structural Equation Modeling Technique

Although Structural Equation modeling is widely used and praised by behavioral scientistic, it has also been criticized for its intrinsic limitations that could alter the quality of results. Literature offers extensive insights on SEM's limitations; however, this section will only reflect on relevant limitations that might have hindered the quality of this study's results.

One of the main limitations is that, as described by Tomarken & Waller (2005), "SEM is only an approximation of reality and that omitting variables that could be implicated in the causal process could result in a misleading picture of the model". Of course, not all potential variables can be included in one model, however, this does not mean that not including some variables, which can be important, will benefit the results. Researchers should be aware of this intrinsic limitation, and it should be acknowledged. The author does it in *Chapter 7.3.2*.

Another limitation of SEM is that there might not be a sole good version of a model, but that other variations of the model can have a good fit as well (Tomarken & Waller, 2003). In fact, this statistical tool cannot tell if the designed model represents the real and complete identity of the included relationships; this is because it can only tell if the proposed model has a good fit or not; however, as just mentioned, many other variations of the model can also have a good fit.

This leads to another pivotal limitation: the inaccuracy of the rule of thumps methods. Rule of thumbs like the optimal cutoff criteria for most fit indices are used to evaluate the goodness of a model and guide decisions; however, they are often oversimplified and erroneous (MacCallum et

al., 2001). As described by Tomarken & Waller (2005), most of the criteria for model fit used in SEM lack a detailed mathematical or empirical justification, and they are subject to several factors, including sample size, model complexity, estimation method, and the degree to which the assumption of multivariate normality is violated. Therefore, evaluating a model based on strict cutoff criteria for fit indices can result in misleading results. A good fit does not represent reality, and it should not be the only way of evaluating a model.

Another limitation commonly limiting SEM studies that might have also limited this study is confirmation bias (Jihye, 2015). This study runs on two similarly complex models that only differ in the domain of one variable; therefore, besides the test and trials conducted throughout the analysis and calibration of the models, this study can only interpret and consider these results. The perfect fit of the saturated model might represent a limitation that misleads the author in accepting such results. Unfortunately, due to the complexity and the time frame used to develop this study, only a set variation of models could have been tested. Results from this study should not be taken as finite findings but as starting points to be re-evaluated and deepened in future studies.

### 7.3.5. The Omitted Role of Different Employment Background in Covid-19 Implications

Due to the lack of this specific type of data, one element not included in this study is the differentiation among employment types in all 354 municipalities. Earlier in this study, *it has been* described that different types of employment change the degree of exposure that an individual has to the Covid-19 virus. Highly skilled employees, also known as white collars, usually coming from a privileged and educated background, had the opportunity to shift to remote working quickly and, therefore, could completely diminish their exposure to the Covid-19 virus. However, essential workers, such as logistics and manufacturing employees and other minimum wage occupations, were less likely to engage in preventive behaviors, such as social-distancing and were forced to experience higher levels of exposure to the virus (Papageorge et al., 2020; Stafford, Hoyer & Morrison, 2020). This level of employment disparity has had drastic implications on essential workers that went through the burden of continuing to work while the rest of society holed up. In fact, throughout the time frame of the pandemic, several cases of Covid-19 clusters were registered on the job site of essential workers (van de Klundert & Start, 2020). The importance of working from home, and the resulting implications of not being able to work from home, is also confirmed by the fact that when several layers of restrictions - such as workplace closure or restrictions on mass gatherings - were in place, the number of Covid-19 cases fell significantly, much more than when governments imposed the closure of public transport services (Islam et al., 2020). As a result, having access to the variables indicating the number of essential and highly skilled workers in each of the 354 municipalities could have helped to catch the conditions that develop disparity in Covid-19 implications between Dutch natives and people with an immigrant background. It could have also helped explain why the majority of the relationships between different ethnic minority groups and Covid-19 variables can be sourced to a direct effect that does not take into consideration the intermediating role of socio-economic, health, spatial, and travel behavior variables.

# References

Abdullah, Muhammad & Ali, Nazam & Dias, Charitha & Campisi, Tiziana & Javid, Muhammad. (2021). Exploring the Traveler's Intentions to Use Public Transport during the COVID-19 Pandemic While Complying with Precautionary Measures. Applied Sciences. 11. 10.3390/app11083630.

Apple. Mobility Trends Reports. (2020). Available from: https://www.apple.com/covid19/mobility.

Abdullah, Muhammad & Dias, Charitha & Muley, Deepti & Shahin, Md. (2020). Exploring the Impacts of COVID-19 on Travel Behavior and Mode Preferences. Transportation Research Interdisciplinary Perspectives. 8. 100255. 10.1016/j.trip.2020.100255.

Afman, E. (2020). Income, Wealth and Intergenerational Inequality in the Netherlands. European Commission - Economic and Financial Affairs. Retrieved from https://ec.europa.eu/info/publications/income-wealth-and-intergenerational-inequality-netherlands_en

Anderson, J.C., & Gerbing, D.W. (1984). The effect of sampling error on convergence, improper solutions, and goodness-of-fit indices for maximum likelihood confirmatory factor analysis. Psychometrika. 49. 155-173.

Andersson, L., Gläfke, A., Möller, T., and Schneiderbauer, T. (2020). *Why Shared Mobility Is Poised to Make a Comeback After the Crisis*. Available online at: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/why-shared-mobility-is-poised-to-make-a-comeback-after-the-crisis (accessed December 16, 2020).

Axhausen, K.W., A. Simma and T.F. Golob. (2001). Pre-commitment and usage: Season tickets, cars and travel. European Research in Regional Science, in press.

Andriessen I. et al. (2015). Rejected on descent, research into discrimination on the The Hague labour market. Retrieved from http://www.NISR.nl/Publicaties/Alle_publicaties/Publicaties_2015/Op_afkomst_afgewezen

APM Research Lab. (2021). THE COLOR OF CORONAVIRUS:COVID-19 DEATHS BY RACE AND ETHNICITY IN THE U.S. Retrieved from https://www.apmresearchlab.org/covid/deaths-by-race

Aloi, A.; Alonso, B.; Benavente, J.; Cordera, R.; Echániz, E.; González, F.; Ladisa, C.; Lezama-Romanelli, R.; López-Parra, Á.; Mazzei, V.; et al. Effects of the COVID-19 Lockdown on Urban Mobility: Empirical Evidence from the City of Santander (Spain). *Sustainability* 2020, *12*, 3870.

Rizzo, Alessandro & Frasca, Mattia & Porfiri, Maurizio. (2014). Effect of individual behavior on epidemic spreading in activity-driven networks. Physical review. E, Statistical, nonlinear, and soft matter physics. 90. 042801. 10.1103/PhysRevE.90.042801.

Almeida, Fernando & Faria, Daniel & Queirós, André. (2017). Strengths and Limitations of Qualitative and Quantitative Research Methods. European Journal of Education Studies. 3. 369-387. 10.5281/zenodo.887089.

Abedi, V., Olulana, O., Avula, V., Chaudhary, D., Khan, A., Shahjouei, S., Li, J., & Zand, R. (2020). Racial, Economic and Health Inequality and COVID-19 Infection in the United States. medRxiv : the preprint server for health sciences, 2020.04.26.20079756. https://doi.org/10.1101/2020.04.26.20079756

Berrond, N. (2020). Coronavirus: why no cluster was detected in transport. Le Parisien.

Board of Academic Advisers to the Federal Minister of Transport and Digital Infrastructure. (2020). Conclusions for future transport policy based on lessons learned from the COVID-19 pandemic and its management.

Bahl, P., Doolan, C., de Silva, C., Chughtai, A. A., Bourouiba, L., & MacIntyre, C. R. (2020). Airborne or droplet precautions for health workers treating COVID-19? The Journal of Infectious Diseases, 1–8. doi:10.1093/infdis/jiaa189

Brauner, Jan & Mindermann, Sören & Sharma, Mrinank & Johnston, David & Salvatier, John & Gavenčiak, Tomáš & Stephenson, Anna & Leech, Gavin & Altman, George & Mikulik, Vladimir & Norman, Alexander & Monrad, Joshua & Besiroglu, Tamay & Ge, Hong & Hartwick, Meghan & Teh, Yee & Chindelevitch, Leonid & Gal, Yarin & Kulveit, Jan. (2020). Inferring the effectiveness of government interventions against COVID-19. Science. 371. eabd9338. 10.1126/science.abd9338.

Belgiawan, P.F., Schmöcker, J.D., Abou-Zeid, M., Walker, J., Lee, T.C., Ettema, D.F., Fujii, S. (2014). Car ownership motivations among undergraduate students in China, Indonesia, Japan, Lebanon, Netherlands, Taiwan, and USA. Transportation 41(6), 1227–1244

Bos, V. (2005). Ethnic Inequalities in Mortality in the Netherlands And the Role of Socioeconomic Status. Netherlands Institute of Health Promotion and Disease Prevention (NIGZ) and the Department of Public Health, Erasmus MC.

Baker MG Thornley CN Mills Cet al. (2010) Transmission of pandemic A/H1N1 2009 influenza on passenger aircraft: retrospective cohort study. 340:c2424.

Bajardi, Paolo & Poletto, Chiara & Ramasco, Jose Javier & Tizzoni, Michele & Colizza, Vittoria & Vespignani, Alessandro. (2011). Human Mobility Networks, Travel Restrictions, and the Global Spread of 2009 H1N1 Pandemic. PloS one. 6. e16591. 10.1371/journal.pone.0016591.

Barbieri DM, Lou B, Passavanti M, Hui C, Hoff I, Lessa DA, et al. (2021). Impact of COVID-19 pandemic on mobility in ten countries and associated perceived risk for all transport modes. PLoS ONE 16(2): e0245886. https://doi.org/10.1371/journal.pone.0245886

Bao, R.; Zhang, A. (2020). Does lockdown reduce air pollution? Evidence from 44 cities in northern China. Sci. Total Environ.

Bos V, Kunst AE, Garssen J, et al. Socioeconomic inequalities in mortality within ethnic groups in the Netherlands, 1995–2000Journal of Epidemiology & Community Health 2005;59:329-335.

Brownstein J Wolfe C Mandl K. (2005). Empirical evidence for the effect of airline travel on inter-regional influenza spread in the United States. *PLoS Med*;

Brooks, Sam & Webster, Rebecca & Smith, Louise & Woodland, Lisa & Wessely, Simon & Greenberg, Neil & Rubin, Gideon. (2020). The psychological impact of quarantine and how to reduce it: rapid review of the evidence. The Lancet. 395. 10.1016/S0140-6736(20)30460-8.

Bird, J., Kriticos, S., & Tsivanidis, N. (2020). Impact of COVID-19 on public transport. ICG. Retrieved from https://www.theigc.org/blog/impact-of-covid-19-on-public-transport/

Carlucci, L., D'ambrosio, I., Balsamo, M. (2020). Demographic and Attitudinal Factors of Adherence to Quarantine Guidelines During COVID-19: The Italian Model. Frontiers in Psychology

CBS (2020). Nearly 9 thousand more people died in the first 9 weeks of the corona epidemic. Retrieved from https://www.cbs.nl/nl-nl/nieuws/2020/20/bijna-9-duizend-meer-mensen-overleden-in-eerste-9-weken-corona-epidemie

CBS (2020). Economic growth of 7.8 percent in Q3 2020. CBS. Retrieved from https://www.cbs.nl/en-gb/news/2020/52/economic-growth-of-7-8-percent-in-q3-2020

Cooley, P.; Brown, S.; Cajka, J.; Chasteen, B.; Ganapathi, L.; Grefenstette, J.; Hollingsworth, C.R.; Lee, B.Y.; Levine, B.; Wheaton, W.D.; et al. (2011). The role of subway travel in an influenza epidemic: A New York City simulation. *J. Urban Health*.

Contrino, Heather & Mcguckin, Nancy. (2009). Demographics Matter: Travel Demand, Options, and Characteristics Among Minority Populations. Public Works Management & Policy. 13. 361-368. 10.1177/1087724X09336223.

Chen, L. H., & Wilson, M. E. (2008). The role of the traveler in emerging infections and magnitude of travel. *The Medical clinics of North America*, *92*(6), 1409–xi. https://doi.org/10.1016/j.mcna.2008.07.005

Care. Smedley BD, Stith AY, Nelson AR, editors. (2003). Washington (DC): National Academies Press (US);PMID: 25032386.

Carethers, J.M. (2020). Insights into disparities observed with COVID-19 (Review). J Intern Med. https://doi.org/10.1111/joim.13199

Charu, V., Zeger, S., Gog, J., Bjørnstad, O. N., Kissler, S., Simonsen, L., Grenfell, B. T., & Viboud, C. (2017). Human mobility and the spatial transmission of influenza in the United States. *PLoS computational biology*, *13*(2), e1005382. https://doi.org/10.1371/journal.pcbi.1005382

Choy, Looi. (2014). The Strengths and Weaknesses of Research Methodology: Comparison and Complimentary between Qualitative and Quantitative Approaches. IOSR Journal of Humanities and Social Science. 19. 99-104. 10.9790/0837-194399104.

Creswell, J. W. (2014). Chapter one - The Selection of a Research Approach. In J. W. Creswell (Ed.), *Research design: qualitative, quantitative, and mixed methods approaches* (4th ed ed.).

Creswell, J. W. (2012). Educational research: Planning, conducting, and evaluating quantitative and qualitative research (4th ed.). Boston, MA: Pearson.

Cham, Heining & Reshetnyak, Evgeniya & Rosenfeld, Barry & Breitbart, William. (2016). Full Information Maximum Likelihood Estimation for Latent Variable Interactions With Incomplete Indicators. Multivariate Behavioral Research. 52. 10.1080/00273171.2016.1245600.

Craig K. Enders & Deborah L. Bandalos (2001). The Relative Performance of Full Information Maximum Likelihood Estimation for Missing Data in Structural Equation Models, Structural Equation Modeling: A Multidisciplinary Journal, 8:3, 430-457, DOI: 10.1207/S15328007SEM0803_5

Docteur, E. & Berenson, R. A. (2014). In Pursuit of Health Equity: Comparing U.S. and EU Approaches to Eliminating Disparities. Timely Analysis of Immediate Health Policy Issues.

De Haas, M., Hamersma, M., & Faber, R. (2020). New insights into mobility and the coronavirus crisis. KiM Netherlands Institute for Transport Policy Analysis. Retrieved from file:///Users/vincenzogiancaspro/Desktop/Brochure_New_insights_mobility_and_the_coronavirus_crisis_English_def.pdf

De Vos, J. (2020). The effect of COVID-19 and subsequent social distancing on travel behavior Author links open overlay panel. Transportation Research Interdisciplinary Perspectives.

D. Acevedo-Garcia. (2001). Zip code-level risk factors for tuberculosis: Neighborhood environment and residential segregation in New Jersey, 1985-1992. Am. J. Public Health 91, 734–741

de Haas, Mathijs & Faber, Roel & Hamersma, Marije. (2020). How COVID-19 and the Dutch 'intelligent lockdown' change activities, work and travel behaviour: Evidence from longitudinal data in the Netherlands. Transportation Research Interdisciplinary Perspectives. 6. 100150. 10.1016/j.trip.2020.100150.

Deepti Muley & Md. Shahin & Charitha Dias & Muhammad Abdullah. (2020). Role of Transport during Outbreak of Infectious Diseases: Evidence from the Past. Sustainability, MDPI, Open Access Journal, vol. 12(18), pages 1-22.

Dzisi, E.K.J.; Dei, O.A. (2020). Adherence to social-distancing and wearing of masks within public transportation during the COVID 19 pandemic. *Transp. Res. Interdiscip. Perspect.*

European Union Agency for Fundamental Rights (FRA). (2020). Coronavirus COVID-19 outbreak in the EU Fundamental Rights Implications, Country: Netherlands. FRA. Retrieved from https://fra.europa.eu/en/publication/2020/covid19-rights-impact-april-1

European Commission, 2020. State Aid SA.58738 (2020/N) – The Netherlands COVID-19 – Support for regional and long-distance public passenger transport.

European Union Agency for Railways. (2020). COVID-19 INFORMATION BULLETIN, VENTILATION IN RAILWAY VEHICLES. Retrieved from https://www.era.europa.eu/sites/default/files/events-news/docs/covid-19_bulletin_ventilation_in_railway_vehicles_en.pdf

European Union Aviation Safety Agency. (2020). Coronavirus 'SARS-CoV-2' Infections – Operational Recommendations. Retrieved from file:///Users/vincenzogiancaspro/Desktop/EASA_SIB_2020-02R4_1.pdf

Elks, S. (2021). How the pandemic has changed our use of public transport. Would Economic Forum. Retrieved from https://www.weforum.org/agenda/2021/05/report-new-initiatives-needed-to-increase-public-transport-usage/

Engle, Samuel and Stromme, John and Zhou, Anson, Staying at Home: Mobility Effects of COVID-19 (2020). Available at SSRN: https://ssrn.com/abstract=3565703 or http://dx.doi.org/10.2139/ssrn.3565703

Ezike, R., Burrowes., K. (2020). Are Cars a Necessity? During COVID-19, Low-Income Households May Consider Public Transit Alternatives. Housing Matters.

Fan, Y., Chen, J., Shirkey, G. et al. (2016). Applications of structural equation modeling (SEM) in ecological studies: an updated review. *Ecol Process* **5,** 19. https://doi.org/10.1186/s13717-016-0063-3

Francesco Burchi. (2006). "Identifying the Role of Education in Socio-Economic Development," Papers of the Annual IUE-SUNY Cortland Conference in Economics, in: Oguz Esen & Ayla Ogus (ed.), Proceedings of the Conference on Human and Economic Resources, pages 193-206, Izmir University of Economics.

Flaxman, S., Mishra, S., Gandy, A. *et al*. (2020). Estimating the effects of non-pharmaceutical interventions on COVID-19 in Europe. *Nature* 584, 257–261 (https://doi.org/10.1038/s41586-020-2405-7

Foxwell A Roberts L Lokuge K Kelly PM. (2009). Transmission of influenza on international flights. *Emerg Infect Dis* 2011; 17:1188–94.

Garaus M, Garaus C. (2021). The Impact of the Covid-19 Pandemic on Consumers' Intention to Use Shared-Mobility Services in German Cities. Front Psychol.

Golob, T.F. and D.A. Hensher. (1998). Greenhouse gas emissions and Australian commuters' attitudes and behaviour concerning abatement policies and personal involvement. Transportation Research D 3, 1-18.

Golob, T. F. (2011). Structural Equation Modeling For Travel Behavior Research. *UC Berkeley: University of California Transportation Center*. Retrieved from https://escholarship.org/uc/item/2pn5j58n

Golob, T.F. and H. Meurs. (1988). Modeling the dynamics of passenger travel demand by using structural equations. Environment and Planning A 20, 1197-1218.

Gross, Cary P., Utibe R. Essien, Saamir Pasha, Jacob R Gross, Shi-yi Wang, Mar- cella Nunez-Smith (2020). "Racial and Ethnic Disparities in Population Level Covid-19 Mortality." Working Paper, Yale School of Medicine, hosted by medRxiv.

Gomes C, McGuire TG. (2003). Identifying the source of racial and ethnic disparities. In: Smedley B, Stith AY, Nelson AR, eds. *Unequal Treatment*. National Academies Press.

Goodwin, R., Gaines, S.O., Myers, L. *et al*. (2011). Initial Psychological Responses to Swine Flu. *Int.J. Behav. Med*. 18, 88–92 https://doi.org/10.1007/s12529-010-9083-z

Gao, Song & Rao, Jinmeng & Kang, Yuhao & Liang, Yunlei & Kruse, Jake. (2020). Mapping County-Level Mobility Pattern Changes in the United States in Response to COVID-19. SSRN Electronic Journal. 10.2139/ssrn.3570145.

Guiraudon, V., Phalet, K. and Ter Wal, J. (2005), Monitoring ethnic minorities in the Netherlands. International Social Science Journal, 57: 75-87. https://doi.org/10.1111/j.0020-8701.2005.00532.x

Haustein, Sonja & Kroesen, Maarten & Mulalic, Ismir. (2020). Cycling culture and socialisation: modelling the effect of immigrant origin on cycling in Denmark and the Netherlands. Transportation. 47. 10.1007/s11116-019-09978-6.

Harris, J. E. (2020). The Subways Seeded the Massive Coronavirus Epidemic in New York City. National Bureau of Economic Research Working Paper No. 27021. Retrieved from http://web.mit.edu/jeffrey/harris/HarrisJE_WP2_COVID19_NYC_24-Apr-2020.pdf

Haug, Nils & Geyrhofer, Lukas & Londei, Alessandro & Hot Dervic, Elma & Desvars, Amélie & Loreto, Vittorio & Conrady, Beate & Thurner, Stefan & Klimek, Peter. (2020). Ranking the effectiveness of worldwide COVID-19 government interventions. 10.1101/2020.07.06.20147199.

Hermida, Richard. (2015). The Problem of Allowing Correlated Errors in Structural Equation Modeling: Concerns and Considerations. Computational Methods in Social Sciences. 3. 1-17.

Hermida, R., Conjar, E.A., Najab, J.A., Kaplan, S.A., & Cortina, J.M. (2010). On the Practice of Allowing Correlated Residuals in Structural Equation Models. Unpublished Manuscript, Department of Psychology, George Mason University, Fairfax, Virginia, United States.

Hooper, Daire & Coughlan, Joseph & Mullen, Michael. (2007). Structural Equation Modeling: Guidelines for Determining Model Fit. The Electronic Journal of Business Research Methods. 6.

Hörcher, D., Singh, R. & Graham, D.J. (2021). Social-distancing in public transport: mobilising new technologies for demand management under the Covid-19 crisis. *Transportation*. https://doi.org/10.1007/s11116-021-10192-6

Hartog, J., & Zorlu, A. (2009). Ethnic segregation in The Netherlands. An analysis at neighbourhood level. International Journal of Manpower, 30(1/2), 15–29.

Harms, Lucas. (2008). Overwegend onderweg: de leefsituatie en de mobiliteit van Nederlanders.

Hong Kong Tourism Board. (2004). *A Statistical Review of Hong Kong Tourism 2004*. HKTB: Hong Kong.

Han, Emeline & Tan, Melisa Mei Jin & Turk, Eva & Sridhar, Devi & Leung, Gabriel & Shibuya, Kenji & Asgari, Nima & Oh, Juhwan & Garcia-Basteiro, Alberto & Hanefeld, Johanna & Cook, Alex & Hsu, Li & Teo, Yik & Heymann, David & Clark, Helen & McKee, Martin & Legido-Quigley, Helena. (2020). Lessons learnt from easing COVID-19 restrictions: an analysis of countries and regions in Asia Pacific and Europe. Lancet (London, England). 396. 10.1016/S0140-6736(20)32007-9.

Islam, N. et al. (2020). Physical distancing interventions and incidence of coronavirus disease 2019: natural experiment in 149 countries. *BMJ* **370**, m2743.

Knight M, Bunch K, Vousden N, Morris E, Simpson N, Gale C et al. (2020). Characteristics and outcomes of pregnant women admitted to hospital with confirmed SARS-CoV-2 infection in UK: national population based cohort study. bmj.

Iyanda, A.E., Boakye, K.A., Lu, Y. et al. (2021). Racial/Ethnic Heterogeneity and Rural-Urban Disparity of COVID-19 Case Fatality Ratio in the USA: a Negative Binomial and GIS-Based Analysis. *J. Racial and Ethnic Health Disparities*. https://doi.org/10.1007/s40615-021-01006-7

Jihye Jeon. (2015). The Strengths and Limitations of the Statistical Modeling of Complex Social Phenomenon: Focusing on SEM, Path Analysis, or Multiple Regression Models. https://doi.org/10.5281/zenodo.1105869

Jones, N. R., Qureshi, Z. U., Temple, R. J., Larwood, J. P., Greenhalgh, T., & Bourouiba, L. (2020). Two metres or one: What is the evidence for physical distancing in covid-19? Bmj, 370, 1–6.

Kaddak, J., Sleat, D., Bennet, A., Wain, R. (2020). Pandemic-Proofing Travel. Tony Blair Institute for Global Change.

Kaplan, D. (2001). International Encyclopedia of the Social & Behavioral Sciences.

Kenny, D. A. (2020). Measuring Model Fit. Retrieved from http://www.davidakenny.net/cm/fit.htm

Karadağ, Engin. (2012). Basic features of structural equation modeling and path analysis with its place and importance in educational research methodology. Bulgarian Journal for Science and Education Policy. 6. 194-212.

Kim, C., Cheon, S.H., Choi, K. *et al.* (2017). Exposure to fear: Changes in travel behavior during MERS outbreak in Seoul. *KSCE J Civ Eng* 21, 2888–2895. https://doi.org/10.1007/s12205-017-0821-5

Kraemer, M.U.; Yang, C.H.; Gutierrez, B.; Wu, C.H.; Klein, B.; Pigott, D.M.; Du Plessis, L.; Faria, N.R.; Li, R.; Hanage, W.P.; et al. (2020). The effect of human mobility and control measures on the COVID-19 epidemic in China.

Khan K Arino J Hu Wet al. (2009). Spread of a novel influenza A(H1N1) virus via global airline transportation. *N Engl J Med*.

Kim JH Lee DH Shin SSet al. (2010). In-Flight Transmission of Novel Influenza A (H1N1). *Epidemiol Health*.

Konstantinos Gkiotsalitis & Oded Cats (2021) Public transport planning adaption under the COVID-19 pandemic crisis: literature review of research needs and directions, Transport Reviews, 41:3, 374-392, DOI: 10.1080/01441647.2020.1857886

Kenny, D. A., & McCoach, D. B. (2003). Effect of the number of variables on measures of fit in structural equation modeling. *Structural Equation Modeling: A Multidisciplinary Journal*, *10*, 333–351. doi: 10.1207/ S15328007SEM1003_1

Kuiper, Malouke Esra and de Bruijn, Anne Leonore and Reinders Folmer, Chris and Olthuis, Elke and Brownlee, Megan and Kooistra, Emmeke Barbara and Fine, Adam and van Rooij, Benjamin, The Intelligent Lockdown: Compliance with COVID-19 Mitigation Measures in the Netherlands (2020). Amsterdam Law School Research Paper No. 2020-20, General Subserie Research Paper No. 2020-02, Available at SSRN: https://ssrn.com/abstract=3598215 or http://dx.doi.org/10.2139/ssrn.3598215

Kumar, Sunil. (2015). Structure Equation Modeling Basic Assumptions and Concepts: A Novices Guide.

Kenny DA. (1979). *Correlation and Causality*. New York: Wiley.

Kim H. Williams & Harsha E. Chacko. (2008). The Effect of Ethnic Differences on Travel Characteristics: An Exploration of Marginality and Ethnicity in Urban Tourism, International Journal of Hospitality & Tourism Administration, 9:2, 147-163, DOI: 10.1080/15256480801907893

Lozzi, G, Rodrigues, M, Marcucci, E, Teoh, T, Gatta, V, Pacelli, V (2020), Research for TRAN Committee – COVID-19 and urban mobility: impacts and perspectives, European Parliament, Policy Department for Structural and Cohesion Policies, Brussels

Lv, Han. (2017). The effects of family income on children's education: An empirical analysis of CHNS data. Research on Modern Higher Education. 4. 49-54. 10.24104/rmhe/2017.04.02002.

Landis,R.,Edwards,B.D.,&Cortina,J. (2009). Correlated residuals among items in the estimation of measurement models.InC.E.Lance&R.J. Vandenberg (Eds.). Statistical and methodological myths and urban legends: Doctrine, verity, and fable in the organizational and social sciences (pp. 195-214). New York: Routledge.

Levine, J., S. Park, R.R. Wallace and S.E. Underwood. (1999). Public choice in transit organization and finance: The structure of support. Transportation Research Record No. 1669, 87-95.

Lucas, Karen & Stokes, Gordon & Bastiaanssen, Jeroen & Burkinshaw, Julian. (2019). Inequalities in Mobility and Access in the UK Transport System. UK Government Office for Science.

Lund Jensen, N., Pedersen, H. S., Vestergaard, M., Mercer, S. W., Glümer, C., & Prior, A. (2017). The impact of socioeconomic status and multimorbidity on mortality: a population-based cohort study. *Clinical epidemiology*, *9*, 279–289. https://doi.org/10.2147/CLEP.S129415

Law R. (2006). The perceived impact of risks on travel decisions. Int J Tour Res.

Lepp A, Gibson H. (2003). Tourist roles, perceived risk and international tourism. *Annals of Tourism Research* 30(3): 606–624.

LeDuc, J. W., & Barry, M. A. (2004). SARS, the First Pandemic of the 21st Century. *Emerging Infectious Diseases*, *10*(11), e26. https://doi.org/10.3201/eid1011.040797_02

Lyon, P.K. (1981). Dynamic Analysis of Attitude-Behavior Response to Transportation Service Innovation. Report 423-II-2 Prepared for the Office of Policy Research, Urban Mass Transportation Administration, Transportation Center, Northwestern University, Evanston, IL.

Mayor of London. (2020). Minority of people failing to wear face coverings on public transport warned 'wear one or face a fine'. Transport for London.

MacCallum RC, Widaman KF, Zhang S, Hong S. (2001). Sample size in factor analysis. *Mul- tivar. Behav. Res*. 36:611–37

Max Roser, Hannah Ritchie, Esteban Ortiz-Ospina and Joe Hasell (2020) - "Coronavirus Pandemic (COVID-19)". *Published online at OurWorldInData.org*. Retrieved from: 'https://ourworldindata.org/coronavirus' [Online Resource]

Marsh, H. W., Hau, K. T., & Wen, Z. (2004). In search of golden rules: Com- ment on hypothesis-testing approaches to setting cutoff values for fit indexes and dangers in overgeneralizing Hu and Bentler's (1999) findings. *Structural Equation Modeling: A Multidisciplinary Journal*, *11*, 320–341.

Ministry of Health, Welfare and Sport. (2021). Coronavirus dashboard. Retrieved from https://coronadashboard.government.nl/over

Ministry of Infrastructure and Water Management. (2018). Key Transport figures 2018. Retrieved from https://english.kimnet.nl/mobility-report/key-transport-figures-2018

Ministers van Onderwijs, Cultuur en Wetenschap. (2019). Rapport De Staat van het Onderwijs 2019. Retrieved from https://www.onderwijsinspectie.nl/documenten/rapporten/2019/04/10/rapport-de-staat-van-het-onderwijs-2019

Mitchell van de Klundert and Reinalda Start. (2020). Employees of the Van Rooi slaughterhouse: we had to work with corona complaints. NOS. Retrieved from https://nos.nl/artikel/2342649-werknemers-slachterij-van-rooi-wij-moesten-werken-met-coronaklachten

Musterd, S., & Van Kempen, R. (2009). Segregation and housing of minority ethnic groups in Western European cities. Tijdschrift voor economische en sociale geografie, 100(4), 599.

Malkanthie, Asoka. (2015). Structural Equation Modeling with AMOS. 10.13140/RG.2.1.1960.4647.

Medimorec N, Enriquez A, Hosek E, Peet K, Cortez A. (2020). Impacts of COVID-19 on Mobility Preliminary Analysis of Regional Trends on Urban Mobility. SLOCAT Partnership

Misa, N. Y., Perez, B., Basham, K., Fisher-Hobson, E., Butler, B., King, K., White, D., & Anderson, E. S. (2020). Racial/ethnic disparities in COVID-19 disease burden & mortality among emergency

department patients in a safety net health system. The American journal of emergency medicine, S0735-6757(20)30845-7. Advance online publication. https://doi.org/10.1016/j.ajem.2020.09.053

Milne, G.J.; Kelso, J.K.; Kelly, H.A.; Huband, S.T.; McVernon, J. (2008). A small community model for the transmission of infectious diseases: Comparison of school closure as an intervention in individual-based models of an influenza pandemic.

McKinsey Center for Future Mobility. (2020). Covid-19 Auto & Mobility Consumer Isights.

Muhammad, S.; Long, X.; Salman, M. (2020). COVID-19 pandemic and environmental pollution: A blessing in disguise? *Sci. Total Environ.*

Merler S Ajelli M. (2010). The role of population heterogeneity and human mobility in the spread of pandemic influenza. *Proc Biol Sci.*

National Association of County and City Health Officials. (2002). Creating health equity 55 The Civil Rights Project at Harvard & Center for Community Change .

Neuman, W. L. (2006). Social Research Methods: Qualitative and Quantitative Approaches 6th Edition, Pearson International Edition, USA.

N., Elangovan & Rajendran, Raju. (2015). Conceptual Model: A Framework for Institutionalizing the Vigor in Business Research. 10.13140/RG.2.1.2164.8484.

N. W. Papageorge et al. (2020). Socio-Demographic Factors Associated with Self-Protecting Behavior during the Covid-19 Pandemic. National Bureau of Economic Research Working Paper Series No. 27378.

Oakil, Abu Toasin & Manting, Dorien & Nijland, Hans. (2016). Determinants of car ownership among young households in the Netherlands: The role of urbanisation and demographic and economic characteristics. Journal of Transport Geography. 51. 229-235. 10.1016/j.jtrangeo.2016.01.010.

Ozturk, Ilhan, The Role of Education in Economic Development: A Theoretical Perspective. Available at SSRN: https://ssrn.com/abstract=1137541 or http://dx.doi.org/10.2139/ssrn.1137541

OECD, Better Life Index. The Netherlands http://www.oecdbetterlifeindex.org/countries/netherlands/

OECD (2018). C. Balestra, and R. Tonkin. Inequalities in household wealth across OECD countries: Evidence from the OECD Wealth Distribution Database. *OECD Statistics Working Papers*, 2018/01. OECD Publishing, Paris.

OECD Statistics (2017). Database on OECD tax receipts and expenditures by level of government. Available at: http://www.oecd.org/ctp/federalism/fiscal-

Oakil, Abu Toasin Md & Manting, Dorien & Nijland, Hans. (2016). Determinants of car ownership among young households in the Netherlands: The role of urbanisation and demographic and economic characteristics. Journal of Transport Geography, Elsevier, vol. 51(C), pages 229-235.

John McLaren. (2020). Racial Disparity in COVID-19 Deaths: Seeking Economic Roots with Census data. NBER Working Papers 27407, National Bureau of Economic Research, Inc.

Otsuki, S.; Nishiura, H. (2016). Reduced risk of importing Ebola virus disease because of travel restrictions in 2014: A retrospective epidemiological modeling study. *PLoS ONE*.

Peugh J, Feldon DF. (2020). How Well Does Your Structural Equation Model Fit Your Data?: Is Marcoulides and Yuan's Equivalence Test the Answer? CBE Life Sci Educ.

Piso R Albrecht Y Handschin P Bassetti S. (2011). Low transmission rate of 2009 H1N1 influenza during a long-distance bus trip. *Infection*.

Płomecka, Martyna & Jawaid, Ali & Radziński, Piotr & Gobbi, Susanna & Neckels, Rachael & Baranczuk, Zofia. (2020). Mental Health Impact of COVID-19: A global study of risk and resilience factors. 10.31234/osf.io/zj6b4.

Pampel FC, Krueger PM, Denney JT. (2010). Socioeconomic disparities in health behaviors. Annu Rev Sociol.

Potoglou, D., & Kanaroglou, P. S. (2008a). Modelling car ownership in urban areas: a case study of Hamilton, Canada. *Journal of Transport Geography*, *16*(1), 42-54.

Pinkster, F. (2008). De sociale betekenis van de buurt [The social meaning of the neighbourhood]. Amsterdam: Amsterdam University Press.

Qureshi, Z., Jones, N., Temple, R., Larwood, J., Greenhalgh, T., Bourouiba, L. (2020). What is the evidence to support the 2-metre social-distancing rule to reduce COVID-19 transmission?. The Centre for Evidence-Based Medicine. University of Oxford.

Rye, Tom & Monios, Jason & Hrelja, Robert & Isaksson, Karolina. (2018). The relationship between formal and informal institutions for governance of public transport. Journal of Transport Geography. 69. 10.1016/j.jtrangeo.2018.04.025.

Ringelheim, Julie. (2009). Collecting Racial or Ethnic Data for Antidiscrimination Policies: A US-Europe Comparison. In: Rutgers Race and the Law Review, Vol. 10, no.1, p. 39-142. http://hdl.handle.net/2078.1/118449

RTL Nieuws. (2020). Coronavirus slaat harder toe in zwakkere wijken: inwoners minder beschermd. Retrieved from https://www.rtlnieuws.nl/onderzoek/artikel/5189278/corona-wijk-achterstand-onderzoek-amsterdam-stadsdeel-cijfers

Research, Information and Statistics (OIS). (2020). Population of neighborhoods by migration background, 1 January 2020. Gemeente Amsterdam. Retrieved from https://api.data.amsterdam.nl/dcatd/datasets/9Ib177KQQ4UgMA/purls/5

Research, Information and Statistics (OIS). (2020). Key figures for neighborhoods, 1 January 2020. Gemeente Amsterdam. Retrieved from ey figures for neighborhoods, 1 January 2020 https://api.data.amsterdam.nl/dcatd/datasets/JN7_TtyHzk70_A/purls/1

Reeves, R., Rodrigue, E., & Kneebone, E. (2016). Five evils: Multidimensional poverty and race in America. Retrieved from https://www.brookings.edu/wp-content/uploads/2016/06/ReevesKneeboneRodrigue_MultidimensionalPoverty_FullPaper.pdf

Sánchez, Thomas W., Stolz, Rich, and Ma, Jacinta S. (2003). Moving to Equity: Addressing Inequitable Effects of Transportation Policies on Minorities. Cambridge, MA: The Civil Rights Project at Harvard University.

Sadik-Khan, J., Solomonow, S. (2020). Fear of Public Transit Got Ahead of the Evidence. The Atlantic. Retrieved from https://www.theatlantic.com/ideas/archive/2020/06/fear-transit-bad-cities/612979/

Signor et al. (2019). MOBILITY AS A SERVICE (MAAS) AND SUSTAINABLE URBAN MOBILITY PLANNING. Retrieved from https://www.eltis.org/sites/default/files/mobility_as_a_service_maas_and_sustainable_urban_mobility_planning.pdf

Siemens Mobility. (2021). Siemens Mobility to develop Mobility as a Service (MaaS) platform for the Netherlands. Siemens.

Sörbom,D. Model modification. Psychometrika,54.371-384.1989.

Shi, D., Lee, T., & Maydeu-Olivares, A. (2019). Understanding the Model Size Effect on SEM Fit Indices. *Educational and Psychological Measurement*, *79*(2), 310–334.

Schumacker, R. E., & Lomax, R. G. (2010). A beginner's guide to structural equation modeling (3rd ed.). Routledge/Taylor & Francis Group.

Savalei, V. (2011). *On asymptotic robustness of NT methods with missing data* (UCLA Department of Statistics papers). Retrieved May 29, 2020, from https://escholarship.org/uc/item/7zt626nh

Sivo, S., & Willson, V. (1998). Is Parsimony Always Desirable? Identifying the Correct Model for a Longitudinal Panel Data Set. *The Journal of Experimental Education, 66*(3), 249-255. Retrieved May 28, 2021, from http://www.jstor.org/stable/20152562

Simon P. (2001). Ethnic Statistics and Data Protection in Council of Europe Countries. Strasbourg: European Commission Against Racism and Intolerance of the Council of Europe. 2007 Seltzer W and Anderson M. . The Dark Side of Numbers: The Role of Population Data Systems in Human Rights Abuses. Social Research, 68(2).

Sharifi, Ayyoob & Khavarian-Garmsir, Amir Reza. (2020). The COVID-19 pandemic: Impacts on cities and major lessons for urban planning, design, and management. Science of The Total Environment. 749. 142391. 10.1016/j.scitotenv.2020.142391.

ShareNow (2020a). *Fakten und Zahlen: Carsharing Während COVID-19*. Available online at: https://www.share-now.com/at/de/corona-carsharing-facts-figures/ (accessed January 9, 2021).

Shamshiripour, Ali & Rahimi, Ehsan & Shabanpour, Ramin & Mohammadian, Abolfazl. (2020). How is COVID-19 reshaping activity-travel behavior? Evidence from a comprehensive survey in Chicago. Transportation Research Interdisciplinary Perspectives. 7. 10.1016/j.trip.2020.100216.

Stafford K, Hoyer M, Morrison A. Coronavirus is killing black Americans at a much higher rate. Available: https://globalnews.ca/ news/6799322/coronavirus-black-americans/

S. Mongey, L. Pilossoph, A. Weinberg. (2020). Which Workers Bear the Burden of Social-distancing Policies? National Bureau of Economic Research Working Paper Series No. 27085.

Sadique, M. Z., Edmunds, W., Smith, R. D., Meerding, W. J., de Zwart, O., Brug, J. Beutels, P. (2007). Precautionary Behavior in Response to Perceived Threat of Pandemic Influenza. *Emerging Infectious Diseases*, *13*(9), 1307. https://dx.doi.org/10.3201/eid1309.070372.

Schmitt-Grohé S., Teoh K., Uribe M. (2020). Covid-19: testing inequality in New York cityhttps://doi.org/10.3386/w27019.

Statistics Netherlands. (2020). Population; key figures. Retrieved from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/37296ned/table?ts=1617100533294

Statistics Netherlands. (2019). Population; key figures. Retrieved from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/37296ned/table?ts=1617100533294

Statistics Netherlands. (2018). Population; key figures. Retrieved from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/37296ned/table?ts=1617100533294

Streeting, M.; Brown, S. (2019). The Economic Benefits of New Mobility for Australia. Available online: https://www.lek.com/ insights/ei/economic-benefits-new-mobility.

Storme, Tom & Casier, Corneel & Azadi, Hossein & Witlox, Frank. (2021). Impact Assessments of New Mobility Services: A Critical Review. Sustainability. 13. 3074. 10.3390/su13063074.

Salverda, W., Haas, C., de Graaf-Zijl, M., Lancee, B., Notten, N., & Ooms, T. (2013). Growing inequalities and their impacts in the Netherlands. (GINI country reports). GINI. http://www.gini-research.org/system/uploads/512/original/Netherlands.pdf?1380138293

Saydah, S. H., Imperatore, G., & Beckles, G. L. (2013). Socioeconomic status and mortality: contribution of health care access and psychological distress among U.S. adults with diagnosed diabetes. *Diabetes care*, *36*(1), 49–55. https://doi.org/10.2337/dc11-1864

Sleutjes, B., de Valk, H.A.G. & Ooijevaar, J. (2018). The Measurement of Ethnic Segregation in the Netherlands: Differences Between Administrative and Individualized Neighbourhoods. *Eur J Population* 34**,** 195–224. https://doi.org/10.1007/s10680-018-9479-z

Syam, A. & Khan, A. & Reeves, Dory. (2012). Demographics do matter: An analysis of people's travel behaviour of different ethnic groups in Auckland. WIT Transactions on the Built Environment. 128. 513-525. 10.2495/UT120441.

Turton, D., Gonzalez, J. (2000). Ethnic Diversity in Europe: Challenges to the Nation State. HumanitarianNet. Retrieved from https://www.corteidh.or.cr/tablas/10698.pdf

Tal, Gil & Handy, Susan. (2010). Travel behavior of immigrants: An analysis of the 2001 National Household Transportation Survey. Transport Policy. 17. 85-93. 10.1016/j.tranpol.2009.11.003.

Tuncer, N., Le, T. (2014). Effect of air travel on the spread of an avian influenza pandemic to the United States. *Int. J. Crit. Infrastruct. Prot.*

Tikkanen, R. FitzGerald, M. Fields, K. Williams II, R.D. (2020). International Health News Brief: Special Issue on COVID-19 and Equity. The Commonwealth Found.

Tintori, G., Alessandrini, A., Natale, F. (2018). Diversity, residential segregation, concentration of migrants: a comparison across EU cities. Findings from the Data Challenge on Integration of Migrants in Cities (D4I), EUR 29611 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79- 98732-8, doi:10.2760/823648, JRC115159.

Tirachini, Alejandro & Cats, Oded. (2020). COVID-19 and Public Transportation: Current Assessment, Prospects, and Research Needs. Journal of Public Transportation, 22 (1): .DOI: https://doi.org/10.5038/2375-0901.22.1.1Available at: https://scholarcommons.usf.edu/jpt/vol22/iss1/1

Torrats-Espinosa G. (2021). Using machine learning to estimate the effect of racial segregation on COVID-19 mortality in the United States. Proc Natl Acad Sci U S A.

Tomarken, A. J., & Waller, N. G. (2005). Structural equation modeling: strengths, limitations, and misconceptions. *Annual review of clinical psychology*, *1*, 31–65. https://doi.org/10.1146/annurev.clinpsy.1.102803.144239

Tomarken AJ, Waller NG. (2003). Potential prob- lems with well fitting models. *J. Abnorm. Psychol.* 112:578–98

The Netherlands. (2010). Health Act (Wet Publieke Gezondheidsorg). available at: https://wetten.overheid.nl/jci1.3:c:BWBR0027466&z=2020-01-01&g=2020-01-01

The Netherlands (2008). Public Health Act (Wet Publieke gezondheid). available at: https://wetten.overheid.nl/BWBR0024705/2019-07-01

Thorbecke, Erik and Charumilind, Chutatong, (2002), Economic Inequality and Its Socioeconomic Impact, *World Development*, 30, issue 9, p. 1477-1495.

USA Facts. (2020). Black Americans make up 13% of the US population. They make up 23% of COVID-19 deaths. Retrieved from https://usafacts.org/articles/covid-deaths-race-state-age-black-hispanic-white/

Underwood, S.K., Handy, S.L., Paterniti, D.A., Lee, A.E. (2014). Why do teens abandon bicycling? A retrospective look at attitudes and behaviors. J. Trans. Health 1(1).

United Nations Economic Commission for Europe (UNECE). (2020). Transport Trends and Economics 2018–2019 Mobility as a Service. Retrieved from https://unece.org/DAM/trans/main/wp5/publications/Mobility_as_a_Service_Transport_Trends_and_Economics_2018-2019.pdf

Van den Bossche, C. (2019). Inequalities in the Netherlands. Netherlands above average in the EU but there are worrying trends. Women Engage for a Common Future (WECF).

van Wissen, L.J. and T.F. Golob. (1992). A dynamic model of car fuel type choice and mobility. Transportation Research B 26, 77-96.

Van Wee, GP., & Banister, D. (2015). How to write a literature review paper? Transport Reviews: a transnational, transdisciplinary journal, 36(2), 1-13. https://doi.org/10.1080/01441647.2015.1065456

van de Velde, Didier & Eerdmans, David. (2016). Devolution, integration and franchising Local public transport in the Netherlands. Urban Transport Group. Inno-V.

Veeneman, Wijnand & Mulley, Corinne. (2018). Multi-level governance in public transport: Governmental layering and its influence on public transport service solutions. Research in Transportation Economics. 69. 10.1016/j.retrec.2018.07.005.

Veeneman, Wijnand & Hirschhorn, Fabio. (2021). A multi-level-governance response to the Covid-19 crisis in public transport. A multi-level-governance response to the Covid-19 crisis in public transport. Submitted to the Journal of Transport Policy.

Verest, Wim & Galenkamp, Henrike & Spek, Bea & Snijder, Marieke & Stronks, Karien & Valkengoed, Irene. (2019). Do ethnic inequalities in multimorbidity reflect ethnic differences in socioeconomic status? The HELIUS study. European journal of public health. 29. 10.1093/eurpub/ckz012.

van Heerde, J. (2020). Discrimineert het coronavirus? Het heeft er alle schijn van. Trouw. Retrieved from https://www.trouw.nl/zorg/discrimineert-het-coronavirus-het-heeft-er-alle-schijn-van~bd7fc9f5/

Vidyakant, Jha & Appasani, Bhargav. (2020). nCOVID-19: Social and Economic Impacts.

Wallenburg, I., Bal, R., Helderman, J. K., Jeurissen, P. (2020). The Netherlands Response to the Coronavirus Pandemic. Erasmus University Rotterdam. Retrieved from https://www.eur.nl/en/news/netherlands-response-coronavirus-pandemic

Wang, J., & Geng, L. (2019). Effects of Socioeconomic Status on Physical and Psychological Health: Lifestyle as a Mediator. *International journal of environmental research and public health*, *16*(2), 281. https://doi.org/10.3390/ijerph16020281

Warren, M.S., & Skillman, S. (2020). Mobility Changes in Response to COVID-19. *ArXiv, abs/2003.14228*.

Wiemers EE, Abrahams S, AlFakhri M, Hotz VJ, Schoeni RF, Seltzer JA. (2020). Disparities in vulnerability to severe complications from COVID-19 in the United States. medRxiv 2020.

Williams, D. R., & Collins, C. (2001). Racial residential segregation: a fundamental cause of racial disparities in health. Public health reports (Washington, D.C. : 1974), 116(5), 404–416. https://doi.org/10.1093/phr/116.5.404

Weill, Joakim & Stigler, Matthieu & Deschenes, Olivier & Springborn, Michael. (2020). Social-distancing responses to COVID-19 emergency declarations strongly differentiated by income. Proceedings of the National Academy of Sciences. 117. 202009412. 10.1073/pnas.2009412117.

Western Sydney University Library. (2017). Literature review purpose. Retrieved from https://www.westernsydney.edu.au/__data/assets/pdf_file/0006/1254786/Literature_review_purpose.pdf

Waarstaatjegemeente. (2019). About Waarstaatjeegemeente. Retrieved from https://www.waarstaatjegemeente.nl/content/over

Williams, C. (2007) Research Methods. Journal of Business & Economic Research, 5, 65-72.

Xu, B., Tian, H., Sabel, C., & Xu, B. (2019). Impacts of Road Traffic Network and Socioeconomic Factors on the Diffusion of 2009 Pandemic Influenza A (H1N1) in Mainland China. *International Journal of Environmental Research and Public Health*, *16*(7), 1223. MDPI AG. Retrieved from http://dx.doi.org/10.3390/ijerph16071223

Yaya, Sanni & Yeboah, Helena & Charles, Carlo & Otu, Akaninyene & Labonté, Ronald. (2020). Ethnic and racial disparities in COVID-19-related deaths: Counting the trees, hiding the forest. British Medical Journal Global Health. 5. 2913. 10.1136/bmjgh-2020-002913.

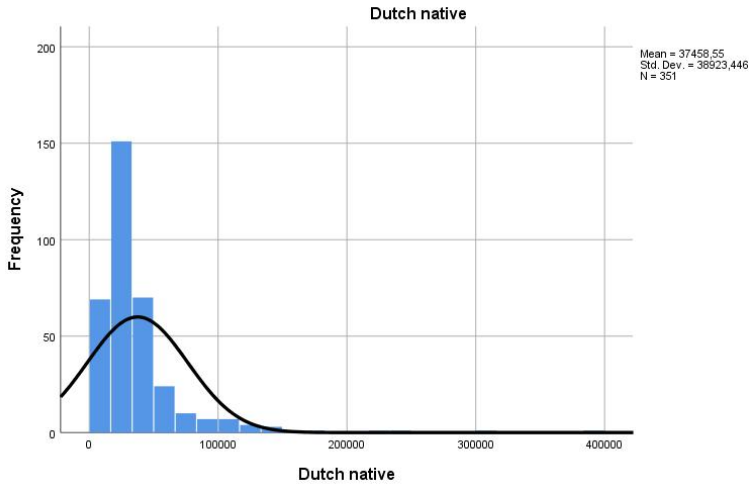
Y. Zhang, Y. Zhang and Z. Liu. (2011). The role of different transportation in the spreading of new pandemic influenza in mainland China. 19th International Conference on Geoinformatics, Shanghai, China, 2011, pp. 1-6, doi: 10.1109/GeoInformatics.2011.5981012.

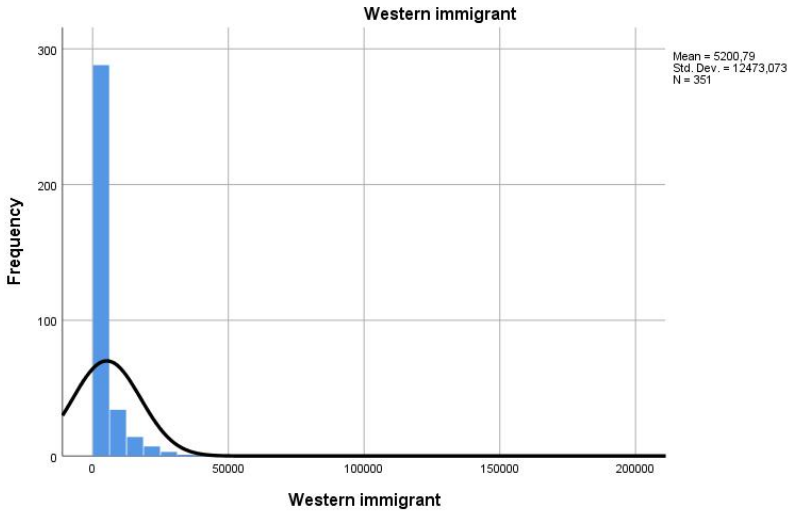
Yancy CW. (2020). COVID-19 and African Americans. JAMA. 2020;323(19):1891–1892. doi:10.1001/jama.2020.6548

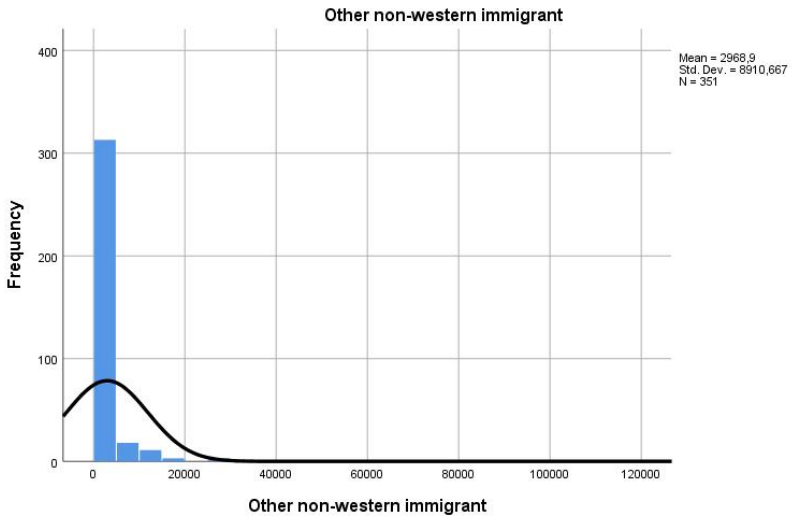
# Appendix A
# *Descriptive Statistics*

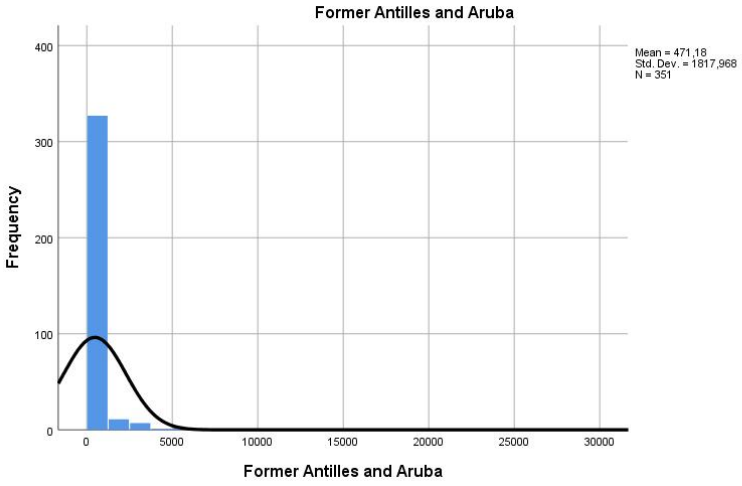
The following are the data distribution histograms of the variables that have been used in this study organized by domain

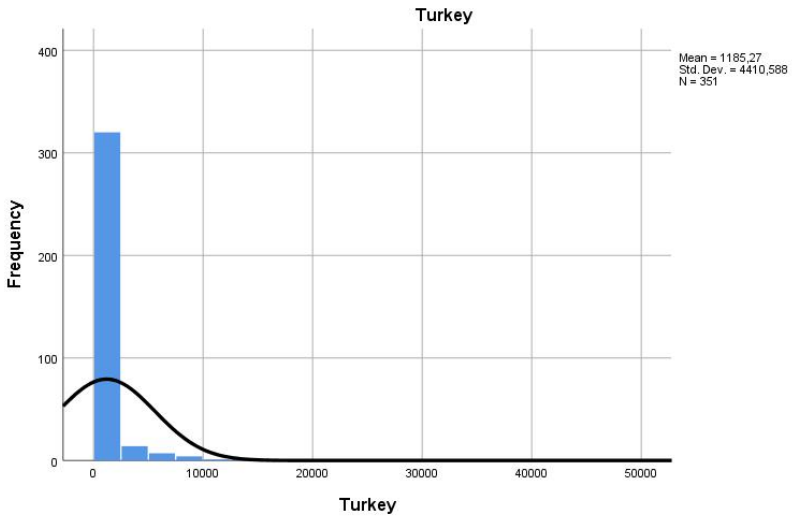
## Ethnicity

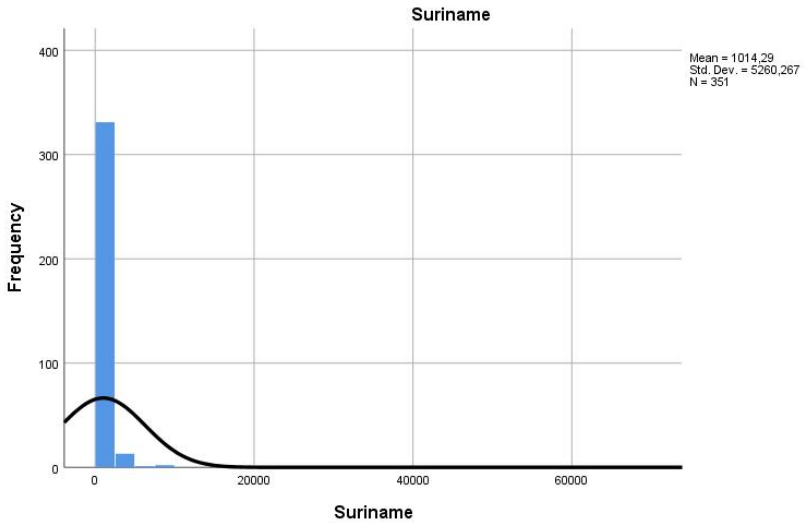


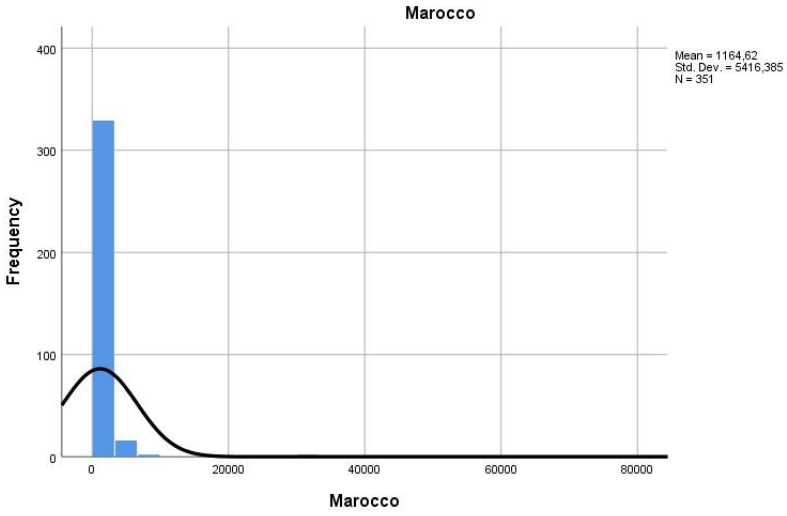




Other non-western immigrant
Mean = 2968,9
Std. Dev. = 8910,667
N = 351
Frequency
400
300
200
100
0
0
20000
40000
60000
80000
100000
120000
Other non-western immigrant

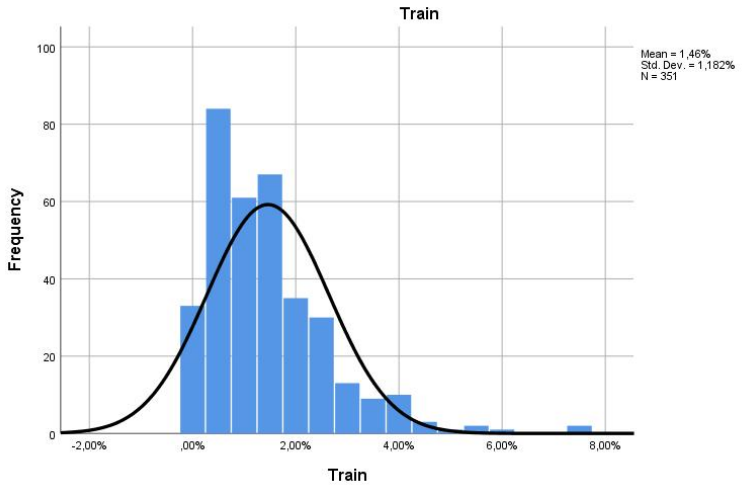

Former Antilles and Aruba
Mean = 471,18
Std. Dev. = 1817,968
N = 351
Frequency
400
300
200
100
0
0
5000
10000
15000
20000
25000
30000
Former Antilles and Aruba

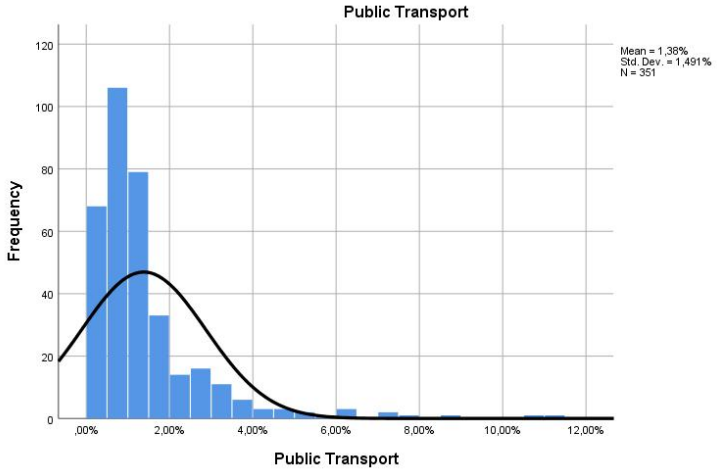

Turkey
Mean = 1185,27
Std. Dev. = 4410,588
N = 351
Frequency
400
300
200
100
0
0
10000
20000
30000
40000
50000
Turkey

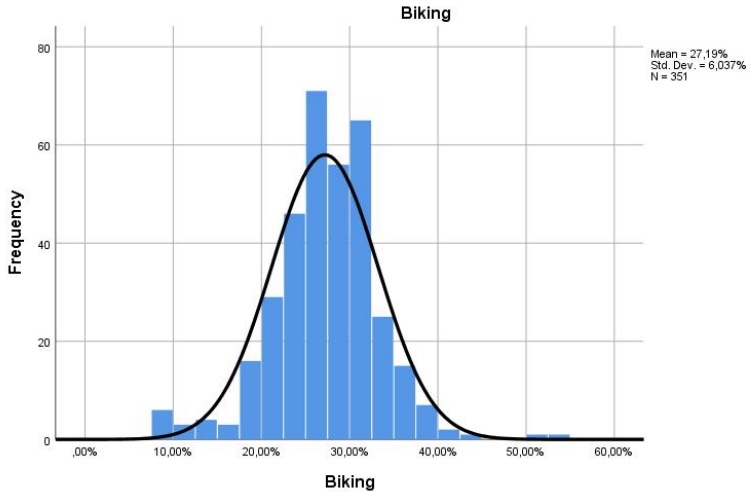

Suriname
Mean = 1014,29
Std. Dev. = 5260,267
N = 351
Frequency
400
300
200
100
0
0
20000
40000
60000
Suriname

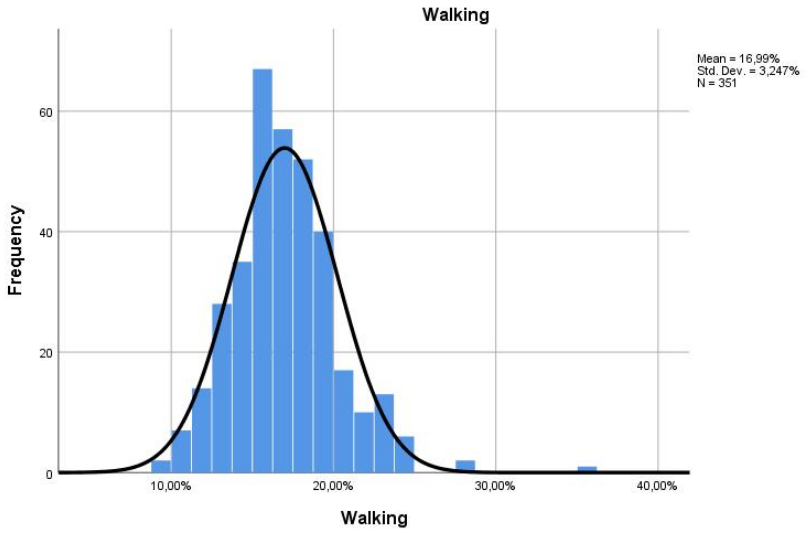

Marocco
Mean = 1164,62
Std. Dev. = 5416,385
N = 351
Frequency
400
300
200
100
0
0
20000
40000
60000
80000
Marocco

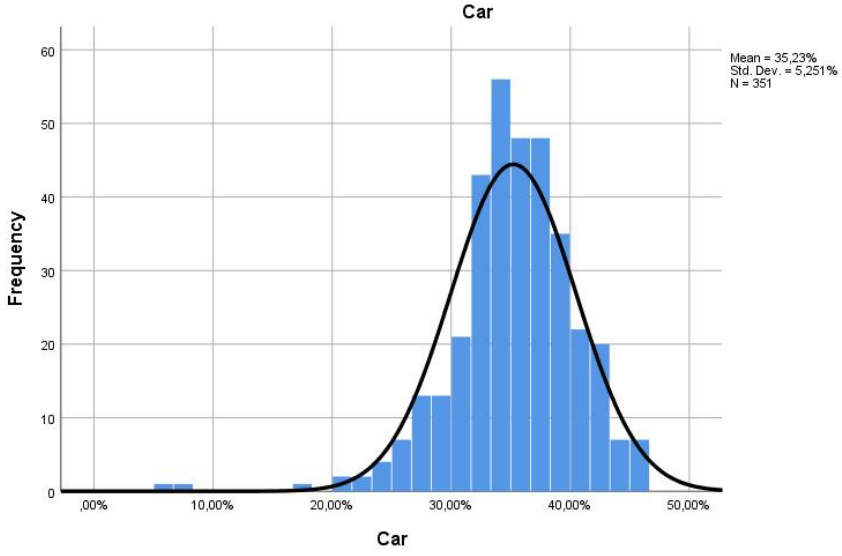
## Travel Behavior



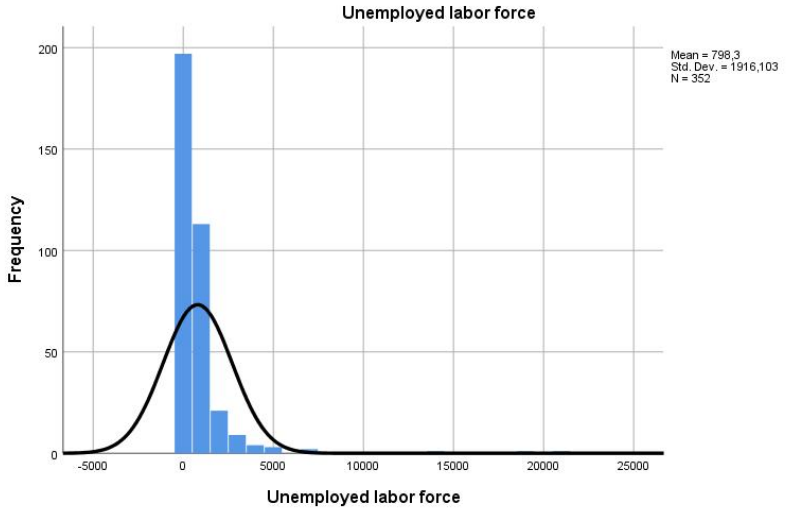



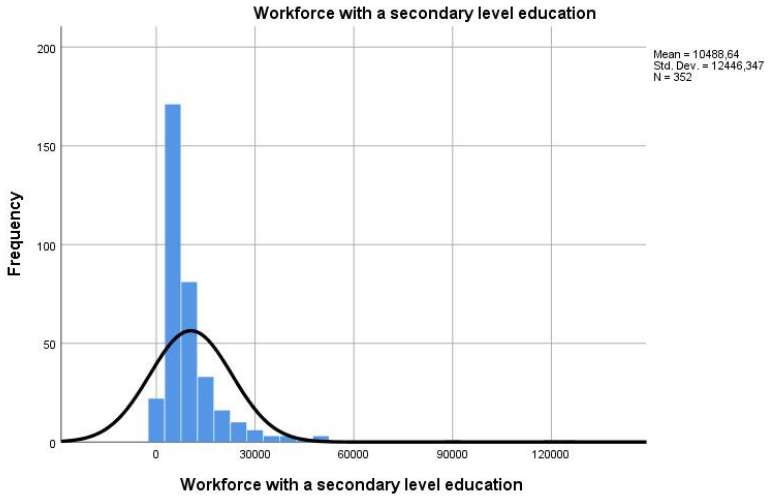



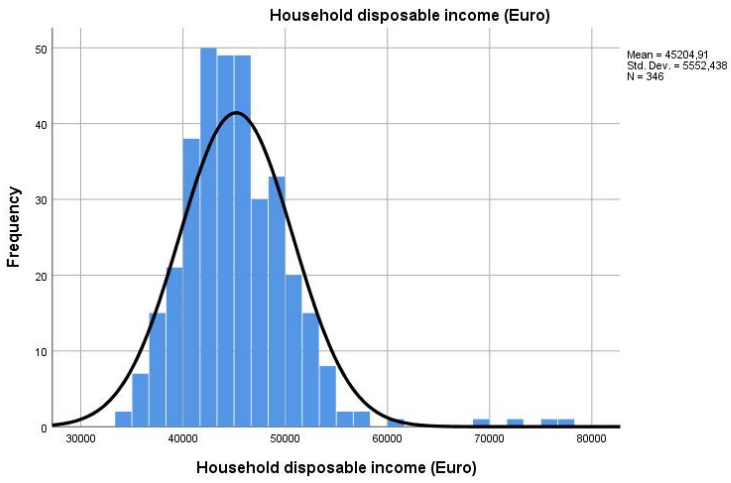

Walking
Mean = 16,99%
Std. Dev. = 3,247%
N = 351
Frequency
60
40
20
0
10,00%
20,00%
30,00%
40,00%
Walking

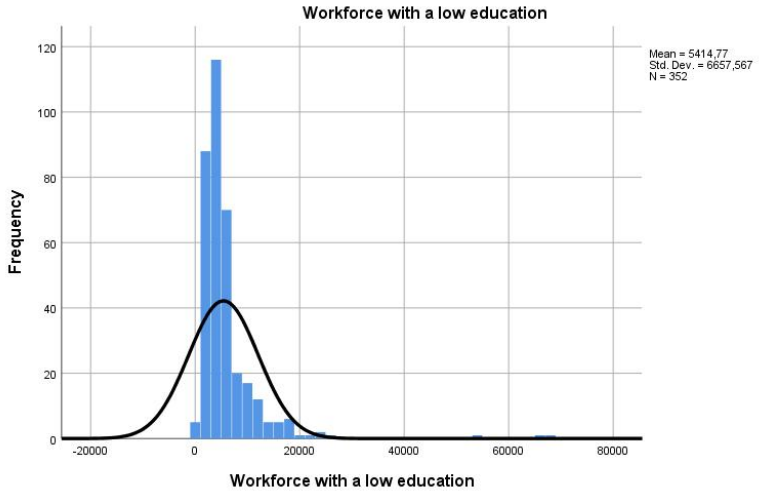

Car
Mean = 35,23%
Std. Dev. = 5,251%
N = 351
Frequency
60
50
40
30
20
10
0
,00%
10,00%
20,00%
30,00%
40,00%
50,00%
Car

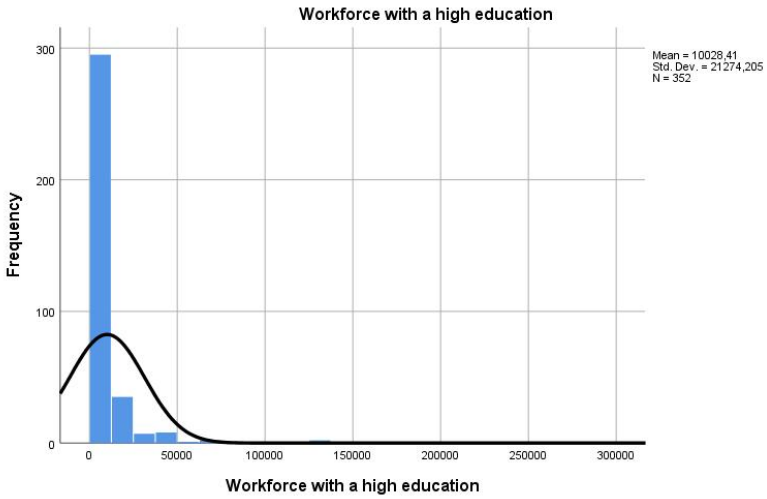
# Socio-economic



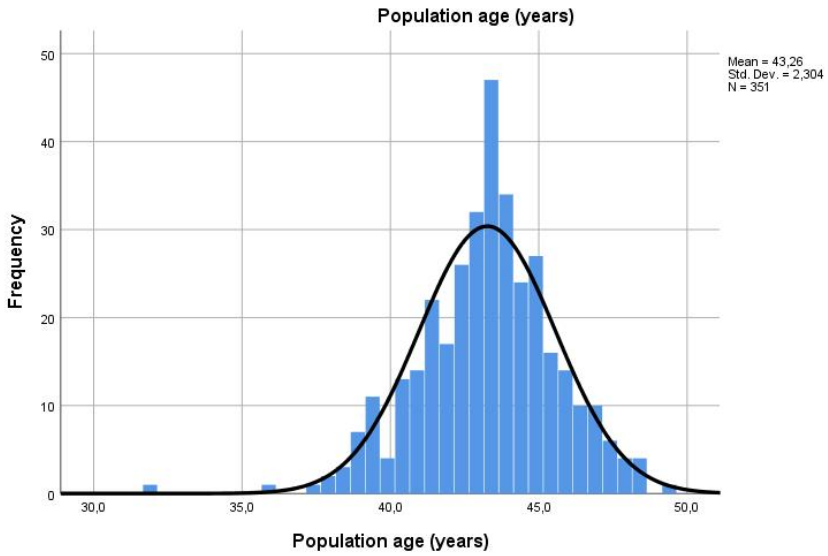



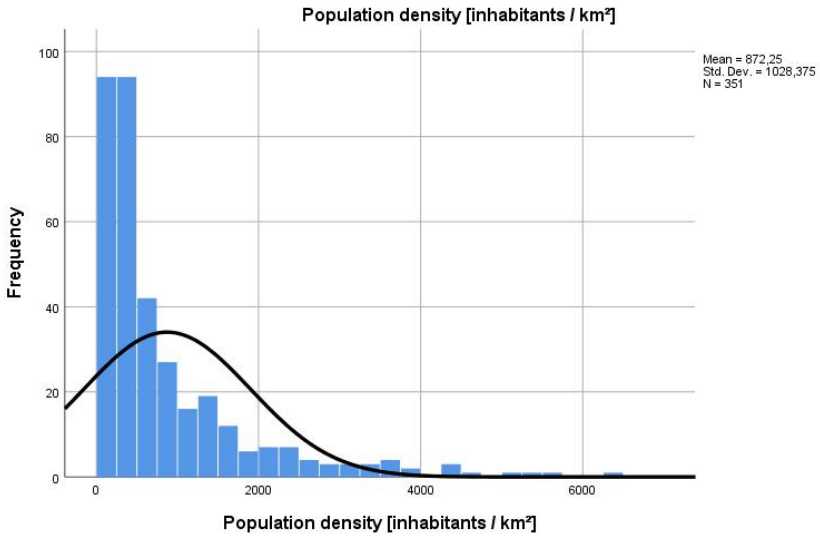



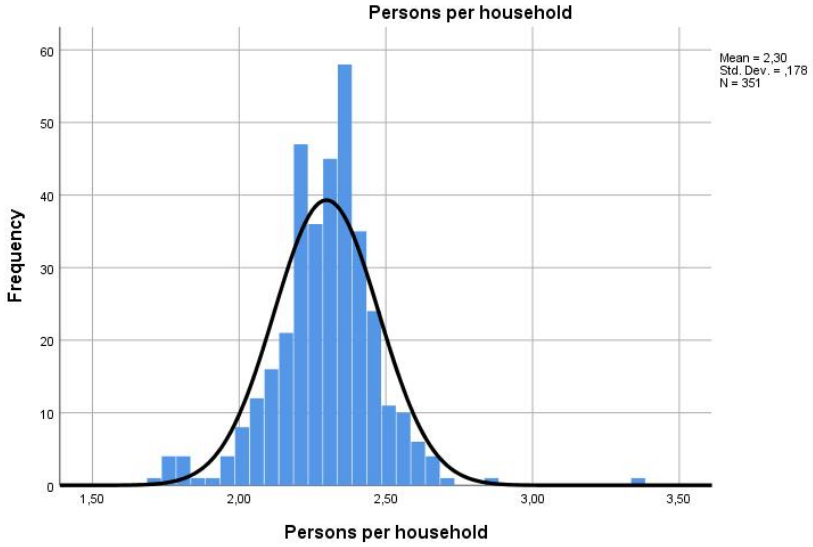

Workforce with a low education
Mean = 5414,77
Std. Dev. = 6657,567
N = 352
Frequency
120
100
80
60
40
20
0
-20000
0
20000
40000
60000
80000
Workforce with a low education


Workforce with a high education
Mean = 10028,41
Std. Dev. = 21274,205
N = 352
Frequency
300
200
100
0
0
50000
100000
150000
200000
250000
300000
Workforce with a high education

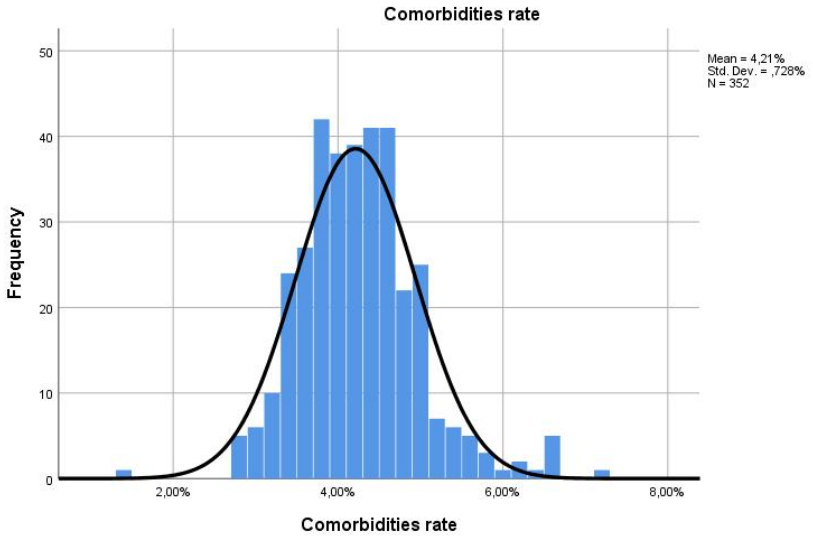
# Demographic

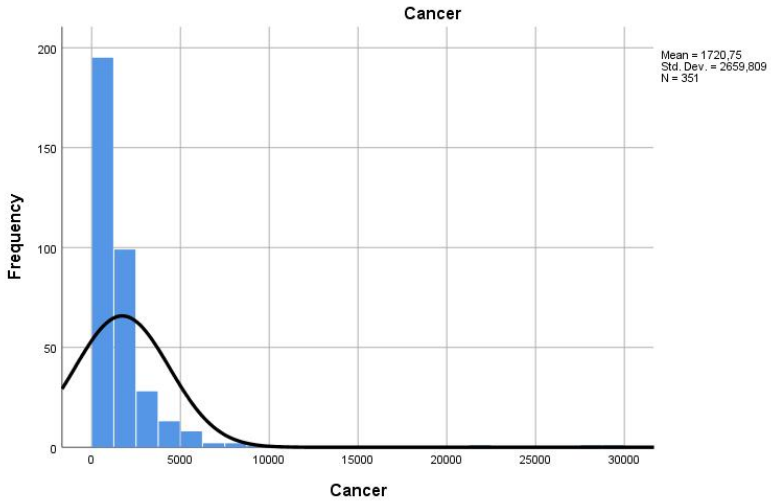


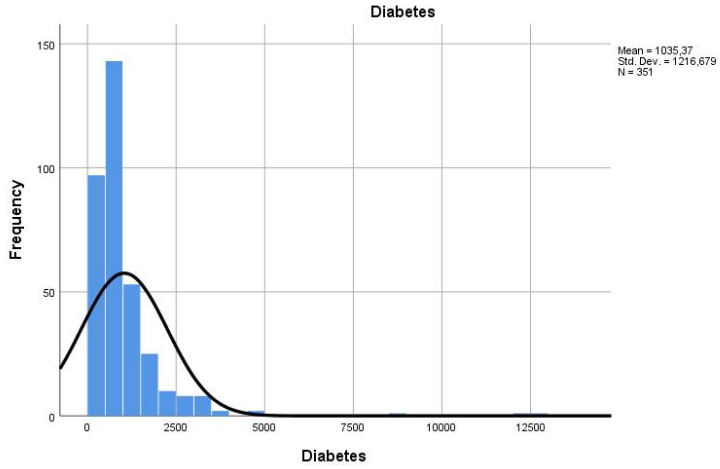



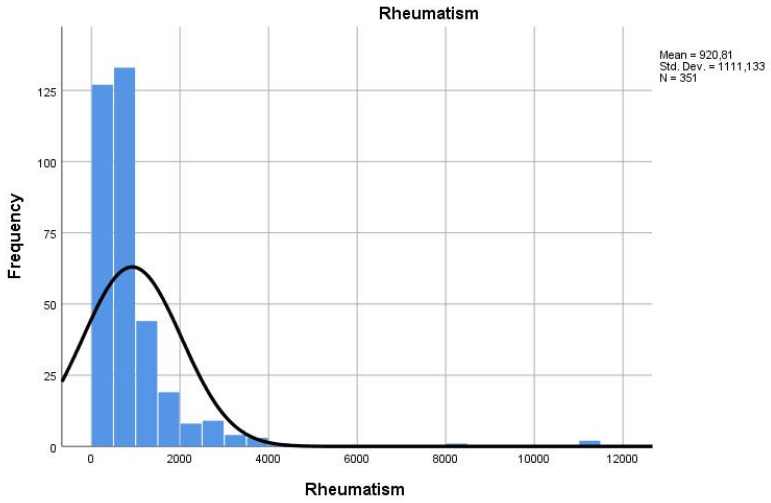

Persons per household
Mean = 2,30
Std. Dev. = ,178
N = 351
Frequency
60
50
40
30
20
10
0
1,50
2,00
2,50
3,00
3,50
Persons per household

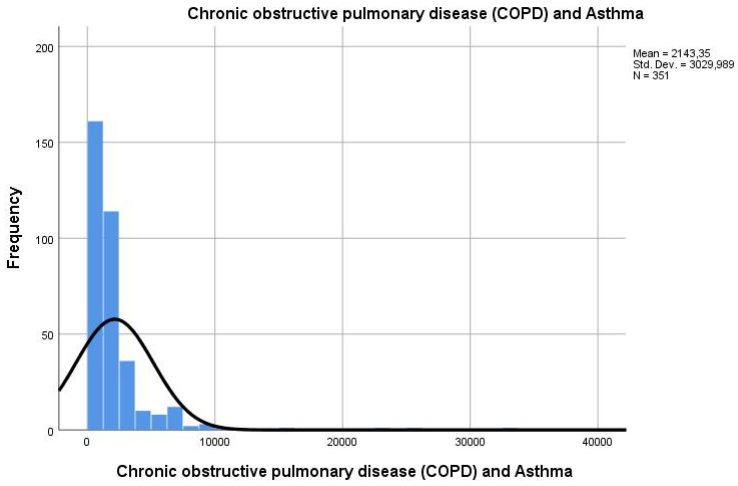
## Health

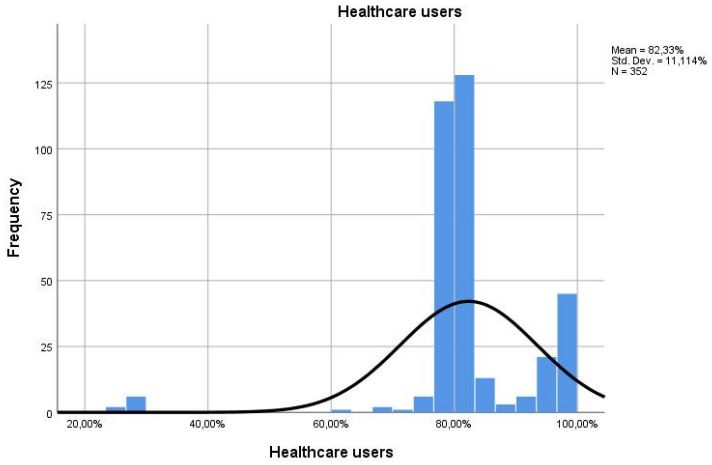

Comorbidities rate
Mean = 4,21%
Std. Dev. = ,728%
N = 352
Frequency
50
40
30
20
10
0
2,00%
4,00%
6,00%
8,00%
Comorbidities rate


Cancer
Mean = 1720,75
Std. Dev. = 2659,809
N = 351
Frequency
200
150
100
50
0
0
5000
10000
15000
20000
25000
30000
Cancer


Diabetes
Mean = 1035,37
Std. Dev. = 1216,679
N = 351
Frequency
150
100
50
0
0
2500
5000
7500
10000
12500
Diabetes


Rheumatism
Mean = 920,81
Std. Dev. = 1111,133
N = 351
Frequency
125
100
75
50
25
0
0
2000
4000
6000
8000
10000
12000
Rheumatism


Chronic obstructive pulmonary disease (COPD) and Asthma
Mean = 2143,35
Std. Dev. = 3029,989
N = 351
Frequency
200
150
100
50
0
0
10000
20000
30000
40000
Chronic obstructive pulmonary disease (COPD) and Asthma


Healthcare users
Mean = 82,33%
Std. Dev. = 11,114%
N = 352
Frequency
125
100
75
50
25
0
20,00%
40,00%
60,00%
80,00%
100,00%
Healthcare users

# Appendix B
# *Model Specifications and Results*

The followings are additional model specifications and results yielded by the study. They have been moved to the appendix because not relevant to this study.

*Figure 11 - Model 1b specifications*

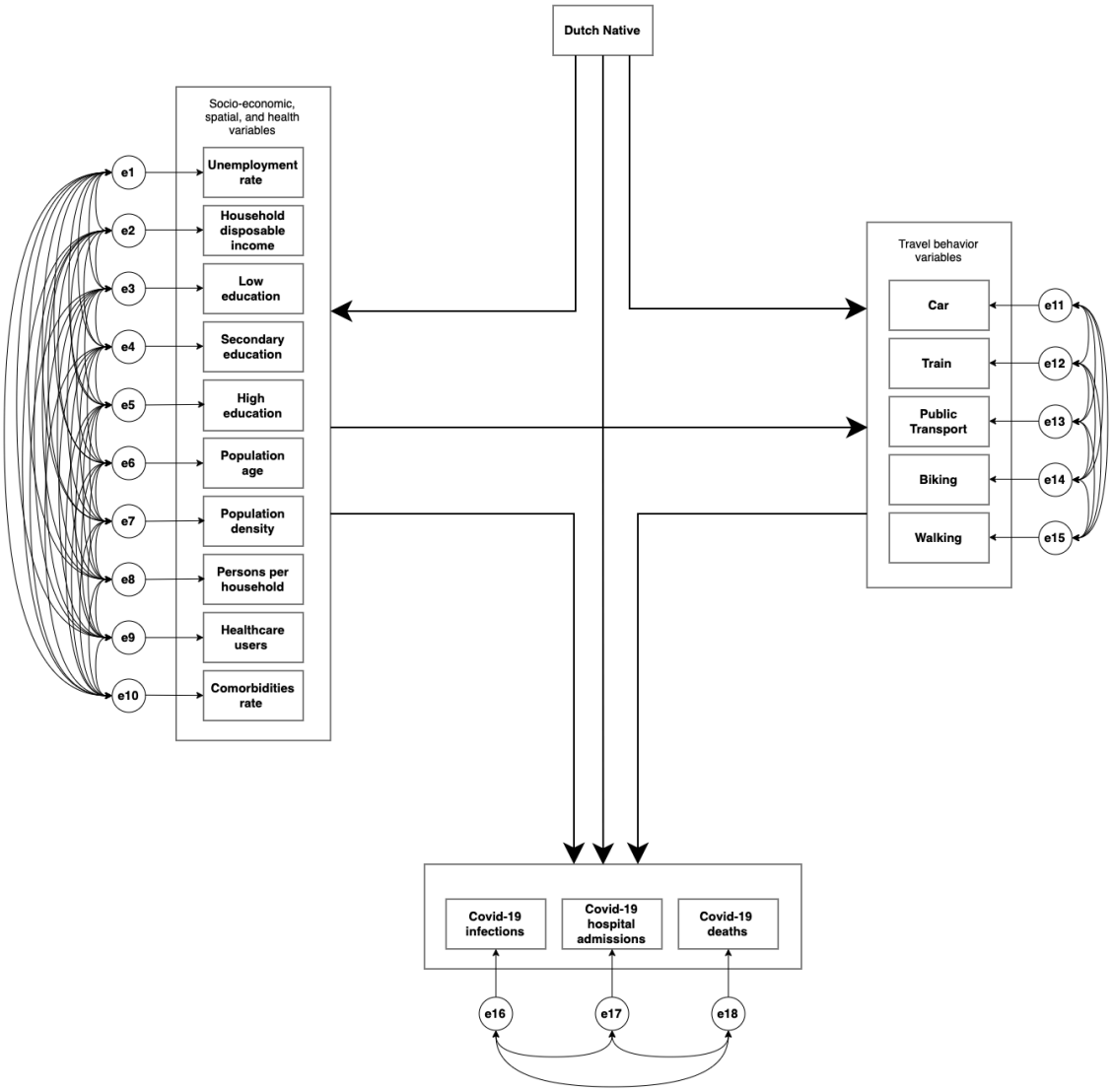


Figure 12: This version of model 1a was the author's attempt into assessing the impact that transforming the Covid-19 variables in latent variable.

*Figure 12 - Model 1a with Covid-19 latent variable*

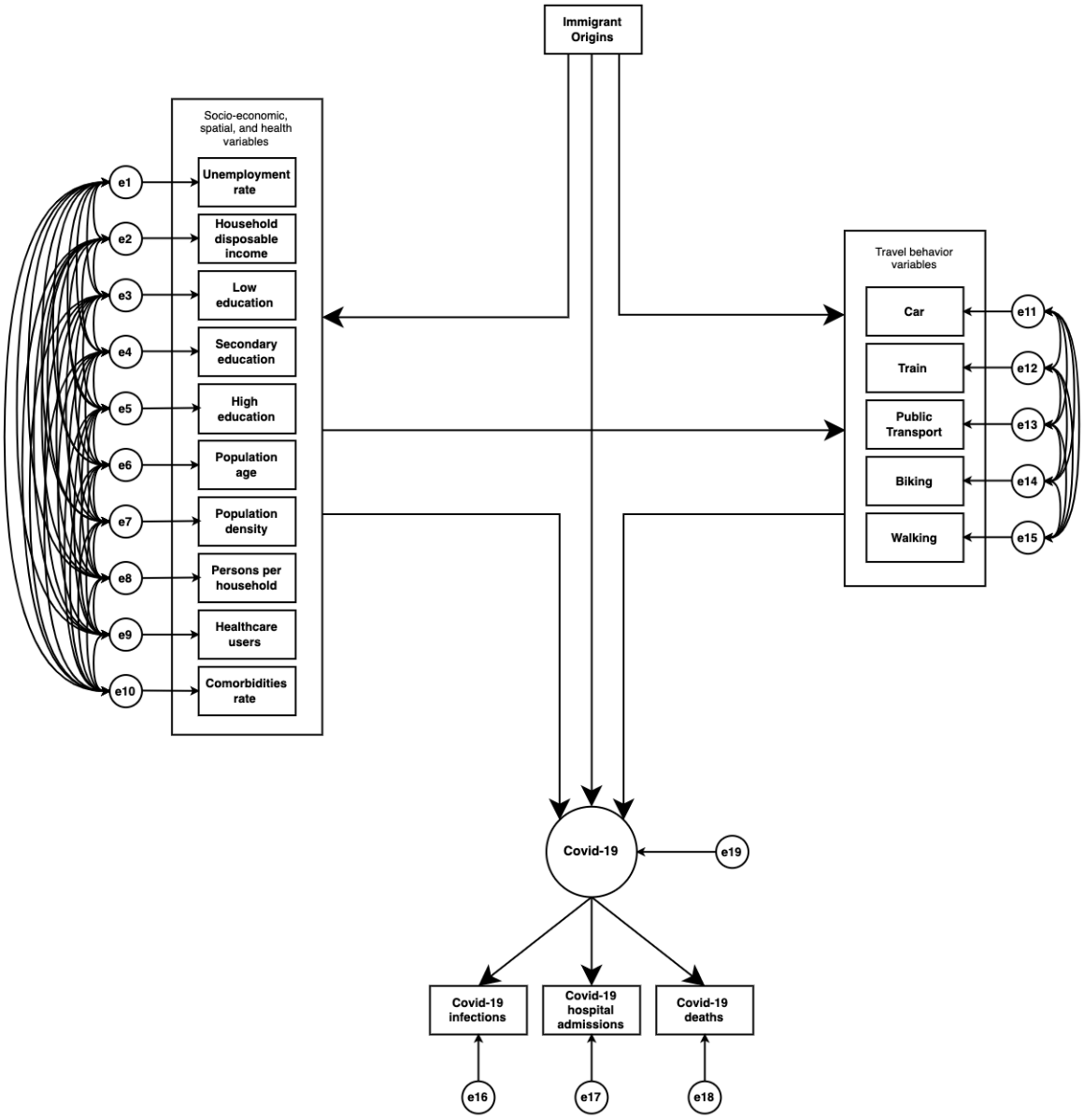


Figure 13: This version of model 2 was the author's attempt into assessing the impact that transforming the Covid-19 variables in latent variable.

*Figure 13 - Model 2 with Covid-19 latent variable*

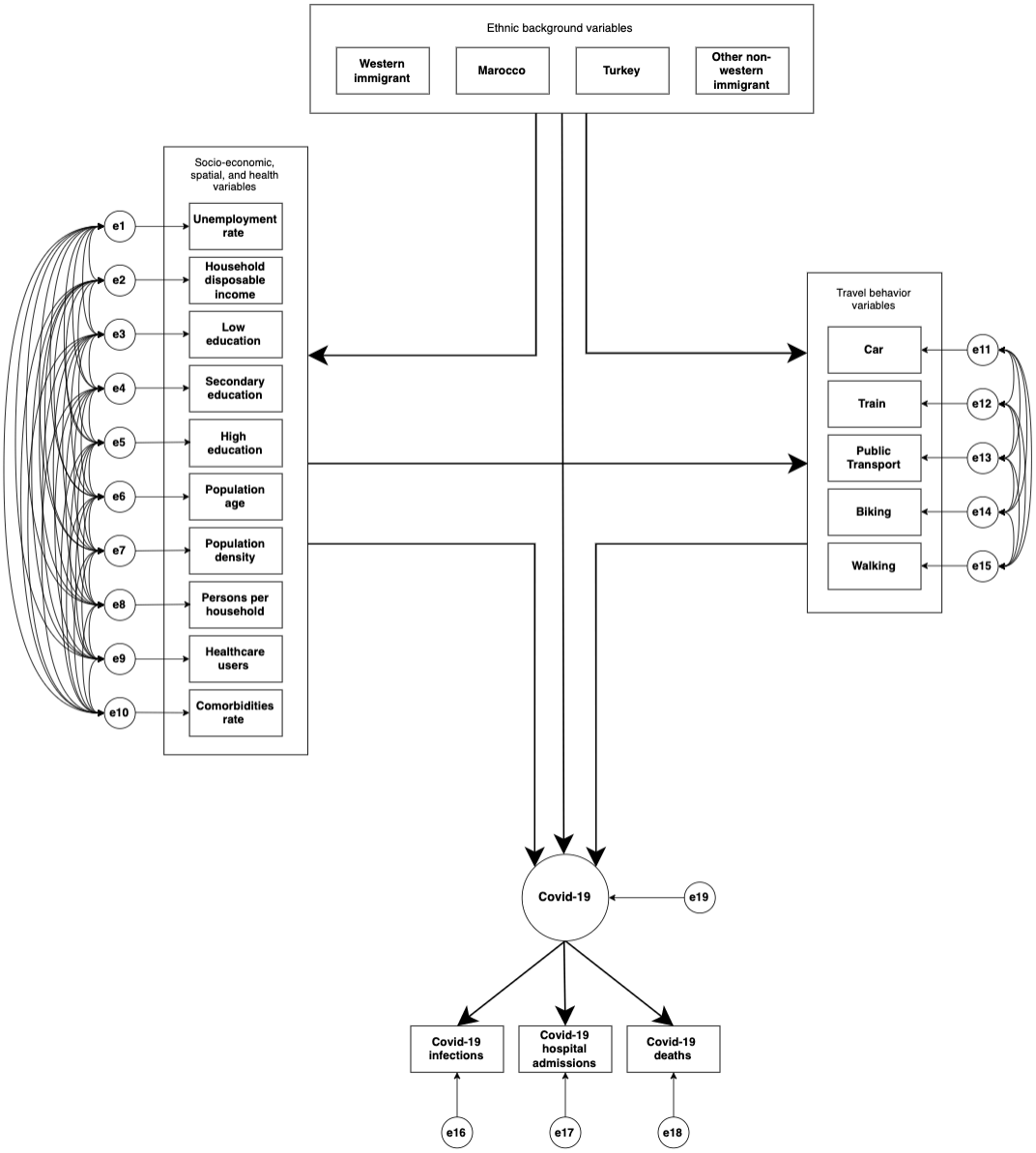


*Table 29 - Standardized direct effects between ethnicity and travel behavior (Model 2)*

| | Other non-western immigrant | Turkey | Western Immigrant | Morocco |
|---|---|---|---|---|
| **Walking** | -162 | -0.026 | 0.162 | 0.172 |
| **Biking** | -0.237 | 0.033 | -0.436 | -0.151 |
| **Public Transport** | 0.536 | -0.119 | 0.123 | 0.031 |
| **Train** | 0.061 | 0.087 | -0.023 | 0.235 |
| **Car** | 0.166 | 0.001 | 0.182 | 0.044 |

*Table 30- Standardized indirect effects between ethnicity and travel behavior (Model 2)*

| | Other non-western immigrant | Turkey | Western Immigrant | Morocco |
|---|---|---|---|---|
| **Walking** | 0.157 | 0.087 | 0.155 | 0.072 |
| **Biking** | 0.418 | -0.046 | -0.026 | 0.157 |
| **Public Transport** | 0.056 | 0.058 | 0.035 | 0.024 |
| **Train** | 0.263 | 0.004 | 0.037 | 0.102 |
| **Car** | -0.505 | -0.018 | -0.023 | -0.203 |