Safe public transport during a pandemic

Transport & Planning bachelor thesis

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Figure 1 on cover:
An artist's impression of College St. retrieved from https://www.stuff.co.nz/business/80092663/te-aro-develops-shared-space-plan-in-bid-to-sidestep-wellington-city-council

Safe public transport during a pandemic

A study focusing on the behavioural change and safety perception of public transport during a pandemic

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By

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Preface

The thesis 'Safe public transport during a pandemic' is part of the bachelor's degree in Civil Engineering at TU Delft. The study, written in the fourth quarter of the academic year 2020/2021, aims to examine the change in safety perception, mode choice and public transport use frequency during the COVID-19 pandemic. To examine this change, a survey was done.

My life has changed a lot due to the COVID-19 pandemic. Before the pandemic, I used public transport every day. But due to the virus and the restrictions imposed by the government, I had to adjust my travel behaviour. This change has also affected my perception of safety when using public transport. I am becoming more and more aware of the dangers that this virus poses, especially regarding the possibility of contamination. I feel less safe using public transport and feel less encouraged to use public transport. Therefore, I wanted to investigate whether this change in perception and in travel behaviour also applies to the general population. I wanted to explore how people's perception of safety has changed and what safety measures can be used to make people feel safer and to encourage them to use public transport during a pandemic.

I would like to thank my two supervisors, Dr.Ir. Yufei Yuan and Dr.Ir. Jisup Shim for their support and their valuable guidance throughout the whole research. I also want to thank my peers. They gave me helpful tips and great feedback throughout the process. Finally, I would like to thank my family and friends and all respondents of my survey. Without all these people, this research would never have been possible.

S.W.Q.S. Blanken
Delft, June 2021

Summary

During the COVID-19 pandemic the life of most of the people has drastically changed. Worldwide, governments had to enact restrictions to contain the virus from spreading. These restrictions have led to a decrease in public transport usage. The perception of safety of using transportation has changed and people feel less encouraged to use public transport because they fear the chance of getting contaminated with the virus.

The report has been set up to answer the following question: ' In what way did the travel behaviour (choice of travel mode and usage frequency of public transport) and the perception of safety of users of public transporters change during the COVID-19 pandemic and how can public transport planners or governments make commuters feel safer and encourage passengers to use public transportation'. To provide a valuable answer to this question several sub-questions are analyzed and answered. The research has 3 main objectives. The first objective was to give an overview of the current situation regarding the safety perception of public transport users and change in the travel behaviour (choice of transportation mode and usage frequency of public transport). The second objective is to determine the factors that influence the perception of safety, choice of transportation mode and usage frequency of public transport. The third objective of the research was to determine what the effect is of safety measures applied in public transport on the perception of safety and if these measures encourage people to use public transport.

The methodology that is used to achieve these 3 main objectives are a literature review, a survey and statistical data analysis. The literature review is used to find an answer for the first two objectives. The analyzed literature gives insight on how the COVID-19 pandemic has changed public transportation. The review shows that people, who feel unsafe during a pandemic, are less encouraged to use public transport. People are opting for other modes of transport instead of public transport during a pandemic. The influential factors of perception of safety and transportation mode choice are identified. The selected influential factors are age, profession, educational degree, habit, ownership of motorized transportation vehicle and safety measures.

The survey is computed to analyze the effect of these influential factors. In total, 92 people filled in the whole survey. The first part of the survey aims to retrieve information about the demographic influential factors of the respondents (age, profession, education degree, ownership of motorized transportation vehicle). The second and third part of the survey the respondents were asked about their travel behaviour before and during the COVID-19 pandemic. In the last part of the survey, 6 different safety measures were applied in six different scenarios. Every respondent needed to answer how safe and encouraged they felt.

Four statistical tests are performed to analyze the survey results. These tests show whether the results of the survey are statistically significant or not. Wilcoxon-signed rank test, Mann-Whitney U test, Spearman correlation and Kruskal Wallis are the test that are used to statistically analyze the results from the survey.

The tests show that people are using public transport less and that the decrease in usage is partially due to the increase in fear to become contaminated when using public transport and that other modes of transportation are used more often namely car and bicycle. Limiting the number of passengers in a transportation vehicle, installing protective screens between passengers' seats and installing disinfection dispensers makes people feel significantly safer and more encouraged to use public transportation during a pandemic.

Content

1. Introduction

In this chapter, the topic of this research will be introduced, and the significance of the research will be described. The chapter starts with describing the problem statement in paragraph 1.1. Then in paragraph 1.2, the objective of the research will be formulated. In paragraph 1.3, the research question, the sub questions and hypotheses are presented. The stakeholders are analyzed in paragraph 1.4 and in paragraph 1.5 the scope is explained. At last, the report setup is described in paragraph 1.6.

1.1 Problem statement

The COVID-19 pandemic, which in 2020 spread around the world, has radically changed the lifestyle of people. Governments had to deploy measures and restrictions to contain the virus from spreading. Every country had another strategy plan but the two main fundamental strategy ideas that were carried out were: Limiting any form of transportation and encouraging social distancing.

Governments took drastic measures that changed the living conditions of people with the purpose to reduce the spreading of the COVID-19 virus (Government of the Netherlands, 2021).

In most places around the world the usage of public transportation has decreased. For example, in the USA the COVID-19 pandemic and the related restrictions led to a major transit demand decline for many public transit systems. In Washington DC the Metrorail ridership declined by 90% and bus ridership declined by 75% by the end of March 2020. This happened because millions of commuters followed the work-from-home orders or choose transportations modes that involved less social contact (Bliss, 2020) (WMATA, 2020).

The main problem this thesis is based on, is the change in travel behaviour and the change of the perception of safety in public transportation (PT) during a pandemic. The COVID-19 pandemic has changed the transportation behaviour of commuters. One of the most prominent changes in travel behaviour that occurred due to the pandemic is the change in the travel mode choice and the change in usage frequency of public transportation. Fewer commuters are using public transportation (Bhaduri, 2020). The reduce in usage of public transportation is not only caused by the imposed restrictions but is also due to fear and the change in the feeling of safety. The safety perception in public transportation during the current COVID-19 pandemic is mainly influenced by the risk of getting contaminated with the virus (Zawierucha, 2021). The public trust in the safety of public transport is declining and trust will be difficult to maintain because people are likely to continue to avoid close physical contact with others. But to ensure that people do not lose faith in the quality and safety of public transport during a pandemic, public transport systems have to meet the commuter's newly formed perception of safety (Cheng, 2020).

In this thesis the behavioural change of users of public transportation during a pandemic and the perception of safety regarding the risk of getting infected are researched. The main research question is: *'In what way did the travel behaviour (choice of travel mode and usage frequency of PT) and the perception of safety of users of public transporters change during the COVID-19 pandemic and how can public transport planners or governments make commuters feel safer and encourage passengers to use public transportation'*. The public tram network of Amsterdam will be used as a real-life example of a COVID-19 strategy. The results of this survey form the basis of a proposal the public transport planners can use to improve their COVID-19 pandemic strategy.

1.2 Objectives

The main objective of this paper is to identify the effect that safety measures have on the perception of safety and the change in the transport mode during a pandemic. This research is of significance because it is crucial for public transport planners to know what the effect is of (potential) safety measures they can apply in order to make commuters feel safe and are encouraged to use public transportation.

The main objective is divided in three parts.

1. Determine the current situation regarding the safety perception of public transport users and change in the travel behaviour (choice of travel mode and usage frequency of PT).
2. Determine the factors that are of influence regarding the safety perception and the travel behaviour
3. Determine which safety measures can be used to make public transport passengers feel safer during a pandemic.

The first objective is achieved by a literature review. The second and third objective will be done by analyzing the data that is obtained from an online survey.

1.3 Research questions and hypothesis

The main research question of this thesis is:

' In what way did the travel behaviour (choice of travel mode and usage frequency of PT) and the perception of safety of users of public transporters change during the COVID-19 pandemic and how can public transport planners or governments make commuters feel safer and encourage passengers to use public transportation'

To find an answer to the research questions, sub-questions are formulated. The goal of posing these sub-questions is to add valuable information that is needed to find an answer for the overall main research question. An explanation to why the sub-question is of significance, is given.

1. *What is changed in the behaviour of public transport commuters(transport mode choice and usage frequency of PT) and what safety measures have been made in general?*

   To give a better understanding to what has changed due to the COVID-19 pandemic, it will be necessary to start with a general analysis of the current situation. This is needed to get a better understanding in the factors that can potentially influence the perception of safety.

2. *What influences the safety perception and transport mode choice?*

   In order to find the answer for the main research question it will be necessary to research how safety and travel behaviour can be changed.

3. *What are the current measures taken by the transport planners to improve the feeling of safety and what are potential safety measures that can be applied in the future?*

   Finding an answer to this sub-question will be necessary because in the survey the impact of these measures will analyzed in the different scenarios.

4. *Does the feeling of safety influences usages frequency of public transport and mode choice?*
5. *Which safety measure contributes the most to the feeling of safety?*

   These questions provide the base for the answer of the main research question. The purpose of question 4 is to research the effect that the perception of safety has on the transportation mode choice and on the usage frequency of

public transport and the purpose of question 5 is to identify the effect of the safety measures. An online survey is done to find an answer for these sub-questions.

6. *In general, what can be improved in the public transportation to make commuters feel safer and how can usage be encouraged?*
7. *In the case of the tram network in Amsterdam, what can be done by the public transport planners to make commuters feel safer?*

Sub-questions 6 and 7 have as goal to use the results of the survey in such a way that the answers to these questions can be used by transport planners and decision makers to improve the public transportation network to encourage people to use public transport and to make them feel more safe when using the transport network. To compare the results of this research to a real-life example, the tram network of Amsterdam will be used. With the results a proposal will be given for the public transport planners that they can use to improve their strategy.

A hypothesis is used to give a testable answer to a scientific answer. Based on the sub-questions and on the created scenarios in the survey several hypotheses are formed. The hypotheses are:

Hypotheses based on the transportation behaviour (usage frequency and mode transportation choice) and on the perception of safety. Statistical test will be executed in order to find out if the hypothesis is statistically correct.

1. The usage of public transport is different during a pandemic than before the pandemic.
2. People, who are in the possession of a motorized vehicle, are less likely to use public transportation during the pandemic then people who don't own a motorized vehicle or a bicycle.
3. Safety score and encouragement score are correlated, if the safety score increases, the encouragement score increases.
4. The average safety/encouragement score is different for different groups (the groups are based on different personal factors, for example Socio-economic and demographic factors).
5. There is no difference between the encouragement scores between the current situation and scenario #.
6. There is no difference between the safety scores between the current situation and scenario #.

1.4 Stakeholders

Regional government, National government, transport planners and transport users are stakeholders that could benefit from the results of this thesis. Government institutions and public transport planners will need to invest in the public transport infrastructure to make citizens feel safe to travel with public transport. This thesis will research what is changed in the perception of safety and what the effect of the different safety measures is. Transport users have a lot of interest in the results of this thesis because the goal is to increase their feeling of safety. In the table 1, an overview is given of all the stakeholders and their interest and influences.

Table 1: stakeholders with their interest and influences

Stakeholder	Interest	Influences
Government institutions	++ Government institutions want to encourage people to keep using public transport during a pandemic.	++
Transport planners	++ Transport planners want to make their service as good as possible and they want to make the passengers feel safer.	++
Transport users	++ Safe feeling when using public transport	0

(-- negative interest or influence, 0 no influence or interest, ++ positive interest or influence)

1.5 Scope

The aim of the research is to identify the effect that the (possible) safety measures in public transportation have on the feeling of safety and on the travel behaviour of public transport users. The study is done under the assumption that the COVID-19 virus is still circulating among us, is contagious and at the time of writing, most of the population has not been vaccinated. It is possible that when this research is done more people are vaccinated but the fear of public transport passengers could still be present.

1.6 Thesis lay-out

This report is divided 7 chapters. The second chapter contains the literature review. In the third chapter, an overview of the methodology that is used to find answers to the all the sub-questions is given. In the fourth chapter of the thesis, the design of the survey is explained. The survey focusses on collecting data on mode choice, usage frequency of public transportation and the effect of different safety measures on the perception of safety of public transportation. In chapter 5 the survey results are presented, and the collected data is analyzed. In the sixth chapter, the discussion about the results and the methodology used is described and a design proposal for the COVID-19 strategy is made. Finally, in chapter 7, the conclusion is stated. The appendix of this research contains the survey questions, the link to the survey and the results of the statistical tests.

2 Literature review

In this chapter the background of the research is given. First the effect that the COVID-19 pandemic has on public transportation is analyzed. Subsequently, choice of transportation mode is described and the factors that influence this choice are presented. After that, the perception of safety will be explained, and the influential factors are analyzed. Finally, the strategy of the public tram network of Amsterdam against the COVID-19 pandemic will be described.

In order to be able to conduct the best possible research, it is important to gather as much prior knowledge as possible. In order to get a clear picture of the perception of safety and the change in transport behavior of people using public transport, a clear analysis is made of the current situation. First, the effect that the COVID-19 pandemic has on public transport is analyzed. Subsequently, the perception of safety is explained and factors that influence this perception are discussed. After that, the current and possible safety measures are discussed in more detail. Subsequently, a selection is made from the influencing factors. The selected influential factors form the basis for the questions and the different scenarios of the survey.

Public transport during a pandemic

Public transportation is one of the sectors on which the COVID-19 pandemic has had a huge impact. Governments have had to enforce massive restrictions on public transportation in order to reduce the possibility of spreading the virus. For example, The city of Johannesburg had to reduce their public transportation busses to run at less than 60% (Diouf, 2020). Studies have shown that by reducing the public transportation network and thus reducing the accessibility, unemployment increases. (Bird, 2020). The COVID-19 pandemic may result in a situation where people don't want to use public transportation because people have concerns about the safety of PT (Vos, 2020).

Choice of transportation mode and usage frequency

Travel behaviour refers to the complicated decision-making process of travellers during a trip, regarding travel mode choice, route choice, departure time choice, destination choice ((Li, 2019). Choice of transportation mode is one of the travel behaviours that has changed the most during the COVID-19 pandemic (Abdullaha, 2020). The choice of transportation mode is influenced by a lot of factors, for example cost of transport, reliability of service, safety, travel frequency, environmental concern and habit influence the choice of transportation mode (Polic, 2009) (Margaret Foddy, 1999) (Ababio-Donkor, 2020). This research focusses mainly on the feeling of safety and the relation between feeling safe and the choice of transportation mode and the usage frequency of public transportation during a pandemic. There is a shift from public transport to private transportation and non-motorized modes (Abdullaha, 2020). An overview of these influential factors is presented in table 2

Table 2: Influential factors of travel behaviour

Travel behaviour (mode choice and usage frequency)
Habit
Ownership of transportation vehicle
Safety
Frequency of the network
Environmental concerns
Cost of transport
Reliability of service

Safety perception

Fear of infection significantly influences travel behaviour. During a pandemic people perceive a higher risk for all types of trips. Safety perception is the subjective evaluation of the risk of a threatening situation based on its severity and features. (Moreira, 2008). The safety perception that is analyzed in this thesis is based on the feeling of safety of getting contaminated with the COVID-19 virus. There are a lot of different factors that influence the feeling of safety. These factors can be categorized in three different categories: situational factors, demographic factors and socio-economic factors. (Delbosc, 2011). Situational factors are external factors. These are the factors that do not occur from within the individual but from elsewhere, for example: physical surrounding and temporal perspective. Examples of physical surrounding factors are safety measures. They change the physical surrounding of an individual, for example; public transport operators apply safety measures in public transportation vehicle to make the passenger feel safer. (Cozens, 2015). Demographic factors provide a general indication of the situation of the person, for example, gender, race, marital status and age. These factors can also influence the feeling of safety of the person. Socio-economic factors are related to the social status of a person. Socio-economic factors that influence the feeling of safety are for example income, education and employment.

An overview of factors that influence the feeling of safety is made in the table 3:

Table 3: Influential factors of the perception of safety

Situational factors	Socio-economic factors	Demographic factors
Physical surrounding (Safety measures)	Income	Age
Temporal perspective	Education	Race
Weather	Employment	Gender
		Marital status

There are a lot of factors that influence the perception of safety. Because of the time frame that is given to this research, not all influential factors can be analyzed. This counts especially to the situational factors. For this category, only the use of safety measures is considered when analyzing the perception of safety.

The safety measures that are used in this thesis are based on the current measures applied by public transport planners and on fictional safety measures that can be applied in the future. Currently, public transport user, with the exception of children up to 12 years old, are obliged to wear face masks and keep 1.5 meter distance between other users (Government of the Netherlands, 2021). Because of the social distancing the capacity of the public transportation has decreased (Vos, 2020). To find a solution to this problem new measures can be introduced in the future that can increase the capacity of public transportation and make the passengers feel safer. The Policy Learning Platform have created 20 possible safety measures that can be utilized in the future. Some of the measures created by the Policy Learning Platform form the basis for the safety measures that are analyzed in this thesis. The mean ideas types, that used in this thesis are to formulate new safety measures, such as: increasing transport frequency, better communication with the passengers and decreasing the spread of the virus (by applying safety measures such as : obligatory hand sanitizing, protective screens and frequent cleaning) (Policy Learning Platform, 2020). Increasing the frequency of public transportation network can be a safety measure if by increasing the frequency of a transportation network, the amount of people inside public transport vehicles decreases.

Selected influential factors

In the chapter 4, the influential factors are used to create different scenarios. The respondent of the survey needs to answer questions about how he/she perceives the applied safety measures. This is done to gain insight into the effect that the measures may have on the respondent. A selection is made from all influencing factors to keep the scope of the thesis focused. The selection of influential factors that will be analyzed in this survey are presented in table 4.

Table 4: Influential factors

Demographic	Socio-economic	Safety measure	Type of safety measure	Transport behaviour
Age	Education degree	Current situation (social distancing + face mask) **Scenario 1**	--	Habit
Gender	Profession	Increased frequency **Scenario 2**	Increasing transport frequency	Ownership of transportation vehicle
	Ownership of transportation vehicle	Hand sanitizing is obliged when entering and leaving public transport **Scenario 3**	Decreasing the spread of the virus	
		Protective screen **Scenario 4**	Decreasing the spread of the virus	
		Real-time update through an app **Scenario 5**	Better communication	
		Frequent cleaning **Scenario 6**	Decreasing the spread of the virus	

It is interesting to analyze potential difference in responses regarding these demographic and socio-economic characteristics of the respondents. The knowledge that is possibly retrieved from analyzing the survey data can help governments with targeting different kind of populations groups for example when starting awareness campaigns. Ownership of transportation vehicle: On of the biggest influential factors on transport behaviour in public transport is the potential ownership of a motorcycle or car. People who own a motorized transport tend to use public transportation less often (Tao, 2019). It will be interesting to see if the new applied safety measures can encourage this target group. The scenarios will be explained in detail in chapter 4 of the thesis.

Strategy of the public tram network in Amsterdam

To combat the COVID-19 virus, public transport planners and the government have created several general safety measures. As of 1 December 2020, wearing a face mask is mandatory on stations and in transport vehicles. People are strongly advised to give other passengers enough space. Passengers cannot travel when they are suffering from a cold and should only travel when it is necessary. In most trams, the driver's cab has been fitted with protective screens and in some station, disinfection dispensers are installed. Because people must travel less, the revenues of the transport network have decreased. To cover the costs, the current strategy needs to be changed (Rijksoverheid, 2021) (9292, 2021).

3 Methodology

In this chapter the methodology that is used to find an answer to the sub- question is described. In paragraph 3.1 the research method is described and in paragraph 3.2 a systematical overview of the used methodology is given.

3.1 Research Method

3.1.1 Survey

A survey has been designed to investigate what influences the usage frequency of public transport and mode choice and to get an insight on the effect that safety measures have on the perception of safety. To achieve the different objectives of this research, the survey has been divided into four parts. The first part of the survey is about personal information. It is important to find out a respondent's background information as this can influence the decision-making progress. The second and third part of the survey is focused on analyzing the effect that the COVID-19 pandemic has on the choice of transportation mode and on the usage frequency of public transportation. The fourth part of the survey is created to analyze the perception of safety regarding several safety measures.

Part 1

The first part of the survey consists of general questions that aim to retrieve personal data of the respondent. Socio-economic and demographic information of the respondent is collected. The collection of this information is mandatory because it will be used to analyze the results.

Part 2 and 3

The second and third part of the survey are designed in such a way that information about the respondent's travel behaviour can be analyzed. This part of the survey focuses on getting information about the choice of transportation mode and the usage frequency of public transportation.

Part 4

To get an insight in the perception of safety, the questions of the survey are structured in such a way that the effect of the various influencing factors can be analyzed. This is achieved by presenting the respondent with different scenarios in which the influencing factors occur. Subsequently, the respondent needs to give a score from 1 to 10 (1 very unsafe -- 10 very safe) on how safe he or she feels regarding the applied safety measure. Giving a score from 1 to 10 is a general and largely accepted concept used for rating situations (Roger D. Wimmer, 2006) . Because the respondent gives a number as answer to most questions, the data can be quantitatively analyzed. The methods of data analysis are discussed in detail later in chapter 2.1.3 .

To distribute the survey two different approaches will be utilized. First of all, the survey will be distributed via social media. It will be spread via Facebook, Instagram, WhatsApp and LinkedIn. The second approach is to make QR codes of the survey and hang them at public transportation stations to try and target more people.

3.1.2 Data analyzing

Cross-tabulation, visualisation and simple computations

The first step in analyzing the data obtained from the survey, is by making cross-tabulation. This method records the relationship between variables and gives a clear overview on the participants responses to the survey questions. To make the collected data more understandable and easier to comprehend the data will also be visualized. For example, when the participants are giving the different scenarios a score on how safe they feel when a safety measure is applied, a histogram is designed that show for the score of safety of all the participants give to the specific scenario. This way trends and interesting patterns can be easily shown. Also, simple computations are made. For example, the average scores given to various scenarios can be calculated, and, in this way, the different measures can be compared to each other.

It is not sufficient to only use the raw data. It is necessary to show that the data that is collected counts for the wider population and that the data is not only applicable for the respondents of the survey. This can be realized by statistical significance analysis.

Statistical analysis

For the statistical analysis multiple formula's will be used. The formulas are retrained from the course Empirical Research Method (Brinkman, 2010).

Statistical significance is related to the probability that the relationship between two variables are not due to chance. The statistical significance is determined by formulating a hypothesis and then statistical test this hypothesis. The tests that are used in this research are the Wilcoxon signed-rank test, Spearman-correlation and the Kruskal-Wallis test. (these are explained later in this chapter). The first step of statistical analysis is to determine which variables you have. There are two main types of variables. Dependent and independent variables. Dependent variables are outcome variables. Independent variables have a causal role or status (e.g. gender). There are different levels in which variables are categorized. Nominal, ordinal, interval and ratio variables. Nominal variables are variables that are mutual exclusive variables that cannot be ordered. Ordinal variables are also variables that are mutual exclusive, but they can be ordered clearly. However, the intervals between the spaces between the different cannot be quantified. Interval variables on the other hand have equal space between them. Ratio variables are another form of interval variable, but they have a meaningful zero point.

To find out if the results of the survey are statistically significant a hypothesis must be formulated that can be tested using a quantitative analysis test. The hypotheses are formulated with the sub-questions in mind. First a null hypothesis is formed. For example, one of the null-hypothesis that is created is: There is no statistical difference in the average safety score of the respondents regarding public transportation before and during the COVID-19. The research hypothesis will be that there is a statistical difference. The independent variable in this hypothesis is the timespan: During or before the COVID-19 pandemic and the dependent variable is the average safety. Then the following research hypothesis is formed. The feeling of safety is changed due to the COVID-19 pandemic. After formulating the hypotheses, the statistical significance can by examined using a P-value. The P-value that is chosen in this research is 0.05. This means that the probability of that a relationship between two variables due to error is 5 in 100. Then one of the statistical tests is used to calculate the computed p value. If after the test, the computed p value is below 0.05, then the null hypothesis can be rejected, and the research hypothesis is correct.

The test that are used in the research are explained below.

Wilcoxon signed rank test

An example of a test that is used in this thesis is the Wilcoxon signed rank test. This test is used when normality in the data cannot be assumed. It is used to compare two sets of scores from the same participants. This test is ideal to analyze the mean of safety and encouragement scores of every scenario. To get a valid result from the Wilcoxon test, it must be checked if the three assumptions are fulfilled. The assumptions are given below.

1. The dependent variable in the hypotheses needs to be measured at the ordinal level.
2. The independent variable in the hypotheses should be related. (same sample is tested for every scenario).
3. The distribution of the difference between the two related groups are symmetrical in shape.

After the assumptions are checked, the Wilcoxon signed rank test can be executed. First the null and research hypotheses are formed, and a degree of confidence is chosen. The degree of confidence or the P-value that is chosen in this research is 0.05. This means that the probability of that a relationship between two variables due to error is 5 in 100. Subsequently the test statistic is computed. The difference between the paired data samples is calculated and then the difference is are ranked according to magnitude. We sum the ranks of the positive and the negative differences and finally we pick the minimum sum as the test statistic. If the computed test statistic is less than the critical value then the null hypothesis is rejected (King, 2019).

Mann-Whitney U test

The Mann-Whitney U test is used to test the equality of means of two independent samples. The two compare samples have an outcome that is not normally distributed and that the samples are relatively small. To get a valid results some 4 assumptions are made:

- The dependent variables are ordinal or continuous
- The independent variables are two categorical and independent groups
- The observations are independent
- The two dependent variables are not normally distributed

The test is computed in SPSS (Laerd statistics, 2021).

Spearman-correlation

Spearman correlation is used to determine if there is a positive or negative linear relationship between two interval variables. It is the non-parametric version of the Pearson correlation. The test can be computed when the data is not distributed normally. The correlation coefficient varies from 1 to -1. If the coefficient is equal to 1 than there is a positive linear relationship and if the coefficient is equal to -1 than there is a negative relationship. The assumptions that must be made to use the Spearman test are the following:

- There is a linear relationship between the two variables.
- All the variables are on interval or ratio level.

SPSS will be used to compute the spearman-correlation (Laerd statistics, 2021).

Kruskal-Wallis

The Kruskal-Wallis test is used to compare the averages scores between three or more independent samples. This test is used when there cannot be assumed that the data is distributed normally. To get a valid result from the Kruskal-Wallis test, the following four assumptions need to be checked:

- The dependent variable is on ordinal, interval or ratio level
- The independent variable contains out of three or more independent samples.
- The observations need to be measured independently.
- The distribution of each sample needs to be similar.

SPSS will be used to compute the Kruskal-Wallis test (Laerd statistics, 2021).

An overview of all the hypotheses with their statistical test are given below.

Wilcoxon ranked signed test

(hypothesis 1)

- H1.0: The usage frequency of public transportation is not different during a pandemic.
- H1.1: The usage frequency of public transportation is different.

(hypothesis 5+6)

- H5.0: There is no difference in the encouragement score between the current situation and scenarios #.
- H6.0: There is no difference in the safety score between the current situation and scenario #.
- H5.1/6.1: scenario 1 has a different (encouragement/safety) score that scenario 2 (Increased frequency).
- H5.2/6.2: scenario 1 has a different (encouragement/safety) score that scenario 3 (Hand sanitizing is obliged).
- H5.3/6.3: scenario 1 has a different (encouragement/safety) score that scenario 4 (Protective screen).
- H5.4/6.4: scenario 1 has a different (encouragement/safety) score that scenario 5 (Real-time update through an app).
- H5.5/6.5: scenario 1 has a different (encouragement/safety) score that scenario 6(Frequent cleaning).

Spearman-correlation:

(hypothesis 3)

- H3.0 There is no relationship between safety score and encouragement score.
- H3.1 There is a relationship between safety score and encouragement score.

Mann-Whitney U test

(hypothesis 2)

- H2.0: People, who are in the possession of a motorized vehicle, are less likely to use public transportation during the pandemic than people who don't own a motorized vehicle or a bicycle.
- H2.1 : There is no difference in the usage frequency of people who do and do not own a motorized vehicle or bicycle.

Kruskal-Wallis

(hypothesis 4)

- H4.0 A: There is no difference in general safety score between educational levels.
- H4.0 B: There is no difference in general safety score between age groups.
- H4.1 A: People with different educational levels give in general a different safety score
- H4.1 B: Older people give a different safety score.

3.2 Systematic overview

The systematic overview of the methodology is described in the picture below

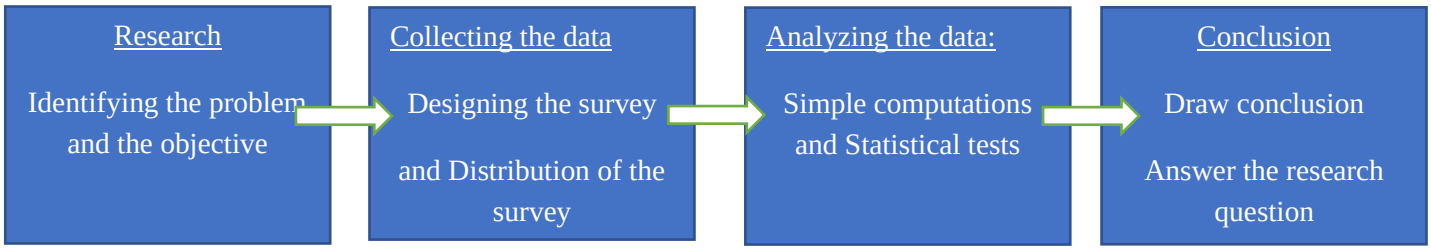

Figure 1: Systematic overview

4 Survey

A survey has been designed to investigate what influences the usage frequency of public transport and mode choice and to get an insight on the effect that safety measures have on the perception of safety. This chapter describes the survey design and explains the 6 different scenarios.

4.1 Survey design

The survey is designed to get an insight in the safety perception of the respondent regarding the influential factors. The first part of the survey aims on retrieving personal data. Questions that are asked are related to the demographic and the Socio-economic influential factors. Then in the second and third part of the survey questions are asked about the transportation behaviour of the respondent before and during the COVID-19 pandemic. In the fourth part, the respondents are presented with 6 different scenarios and the respondent has to rate each scenario on how safe they feel and how encouraged the respondents feel to use public transport

Part 1: Demographic questions:

The first part of the survey is related to the personal information of the respondent. Question about the socio-economical and demographic information are asked. Results about age, gender, educational level, profession and possible possession of transport vehicle are needed to answer hypotheses 2 and 4.

Part 2 & 3: Transportation behaviour questions:

The second and third part of the survey aim to find data about the transport behaviour of the respondent. In the second part question regarding the usage of public transport and choice of transportation mode before the COVID-19 pandemic are asked. In third part aims to retrieve the same information (usage frequency and choice of transportation mode) during the COVID-19 pandemic. The results are needed to for hypotheses 1and 3.

Part 4: The scenarios

In the final part of the survey, the respondent needs to give 6 different scenarios a score from 1 to 10 based on the feeling of safety (1 very unsafe – 10 very safe). The respondent is also asked to give the scenario a score from 1 to 10 based on the encouragement feeling (1 not encouraged to use public transport – 10 encouraged to use public transport). The results are used to find an answer for hypotheses 5 and 6. The different scenarios are explained on the next page.

Scenario 1:

Figure 2: Current safety measures (scenario 1)

Scenario 1 is a representation of the current situation. Passengers are obliged to wear face masks and social distancing is applied. Passengers aren't allowed to sit next to each other. In Scenario's 2,3,4,5 and 6 the current safety measures of scenario 1 are still applied and one extra safety measure is introduced.

Scenario 2:

Figure 3: Increasing the frequency of the transportation system (scenario 2)

The safety measure that is applied in scenario 2 is increasing the frequency of the transportation network. The prediction made by the Policy Learning Platform says that by Increasing the transportation frequency will lead to fewer passengers per vehicle. This way passengers are sitting with fewer passengers in one vehicle and the chance of getting infected with the COVID-19 virus is reduced (Policy Learning Platform, 2020). The passengers that are erased from the picture (colored in white) are not in the transport vehicle anymore because of the increased frequency, there are fewer people in the public transportation vehicle.

Scenario 3:

Figure 4: Hand sanitizing is obliged (scenario 3)

The safety measure that is visualized in figure 4 is mandatory hand washing when entering and leaving a transport vehicle. Every transportation vehicle will have an alcohol spray dispenser. Passengers are obliged to wash their hands when entering and leaving the vehicle to reduce the change of spreading the virus.

Scenario 4:

Figure 5: protective screen (scenario 4)

The safety measure that is applied in scenario 4 is the installation of protective screens. Between every passenger protective screen will be placed to reduce the chance of getting infected.

Scenario 5:

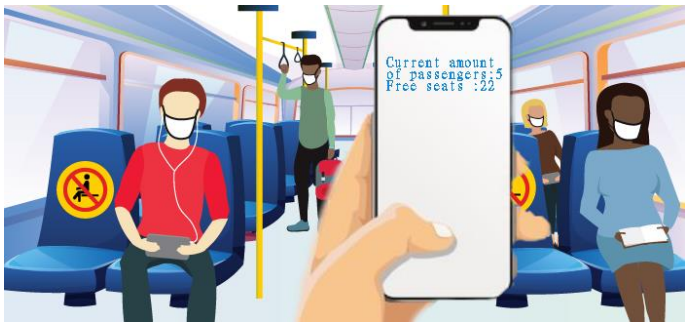

Figure 6: Real-time update through an app (scenario 5)

In this scenario, an app is created by the transportation operators that show how many passengers there are in the transportation vehicle and how many seats are still available. This way the passengers can choose if he wants to travel with public transport based on real-time data.

Scenario 6:

Figure 7: frequent cleaning (scenario 6)

The safety measure in scenario 6 is the following: In every transportation vehicle a member of the cleaning staff is placed. They clean the used surfaces and the new available seat when someone leaves the transportation vehicle.

The survey questions

The respondents are asked questions about their transportation behaviour before and during the COVID-19 pandemic. For example: 'How often did you use public transportation before the COVID-19 pandemic and how often do you use public transportation during the COVID-19?'. Additional questions are asked to make an assumption on why the transportation behaviour has changed.

For every scenario the respondent is asked to answer two questions:

1. Regarding the current measures , give a score from 1 to 10 on how safe you feel. (1 very unsafe – 10 very safe)
2. Due to the safety measure of this scenario I feel more encouraged to use public transportation (1 strongly disagree – 10 strongly agree)

Because the respondent needs to answer the question with a number the received data from the survey can be quantitively analyzed and with the use of simple computation the effect of the different measures can be easily compared. The overview of all the survey questions is added to the Appendix.

5 Data analysis

In this chapter the data received from the survey is presented and analyzed. After the analysis several conclusions are made regarding the hypothesis formed in chapter 1. The statistical tests compute the statical significance of the results. In the paragraph 5.1 the general results are presented and analyzed. Subsequently, in paragraph 5.2 the results from the statistical tests are shown and in paragraph 5.3 a summary of the analysis is made.

5.1 Survey result

General comments

They survey has a total of 101 respondents. Unfortunately, 9 surveys were not filled in the complete survey. To ensure that the missing data do not lead to erroneous conclusions, these surveys were not included in the analysis. That is why there are only 92 questionnaires analyzed. An explanation to why 9 surveys were incomplete is given in chapter 6.

Socio-demographic groups

The survey has 92 respondents from different age groups and educational levels. These results are shown in the three pie charts in figure 8.

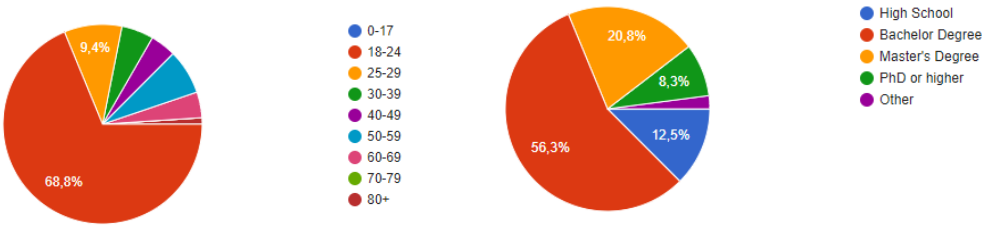

Figure 8: Pie chart of the distribution of respondents based on age (left) and educational level (right).

As can be seen in the figure above, the majority of the respondents are from the age group 18-24, are students and have a bachelor's degree. The reasons for this are that due to COVID-19 pandemic, the survey was mainly distributed via social media and other online platforms. Initially, the distribution across the different Socio-economic groups was more uneven, but this was reduced by adjusting the distribution method of the survey. To improve the distribution between the different age groups, the survey was delivered to several retirement homes. The residents could scan a QR-code that brought them to the survey. This increased the older groups slightly. To improve the distribution between the educational groups, the survey was sent in different university and college chat groups. This led to a more evenly distributions between the different educational levels.

Although the different groups are not evenly distributed, the data can be used to investigate what the effect is of these demographic factors have on the perception of safety in public transport. This data will be used to test hypothesis 4A and 4b.

Hypothesis 4A: '*There is no difference in general safety score between educational levels'*

Hypothesis 4B: '*There is no difference in general safety score between age groups*.

The average safety score per age group is calculated in figure 9 . It can be concluded that the average safety score is lower for older respondents than for younger respondents the blue dotted line in figure 9 shows the decrease in average safety score between the different age groups. This could mean that the average safety score given by a respondent decreases when the respondents gets older. This may be because older people have poorer health than younger people and are therefore more cautious. However, it is interesting to note that there is an increase in safety score between the two groups of 19-24 and 25-29. The significance of these results will be computed in paragraph 5.2.4. .

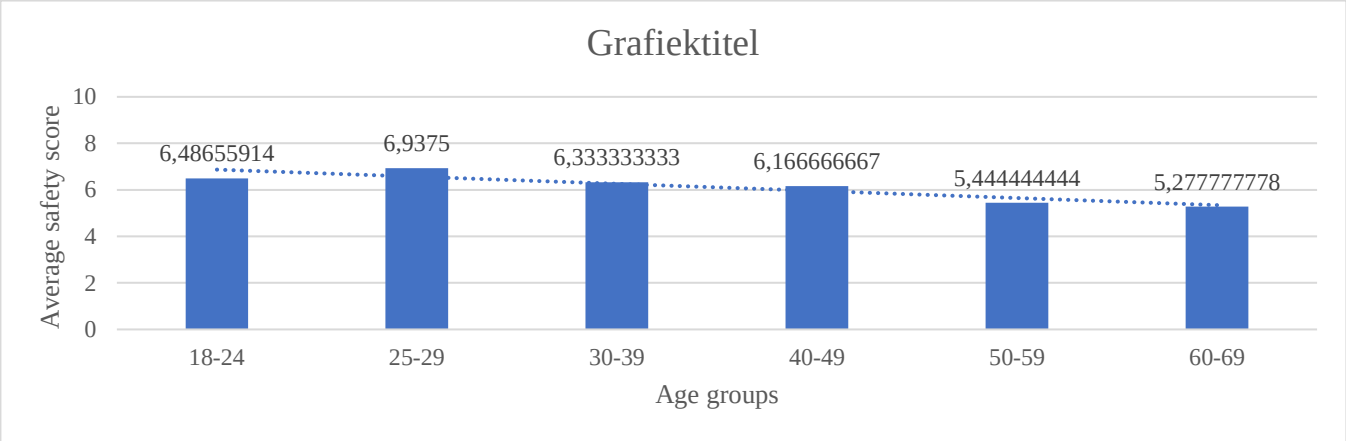

Figure 9: Average safety score of different age groups

In figure 4, the average safety score per educational degree is visualized. The respondents that have completed their PhD have the highest average safety score. Previous research has shown that higher educated people have in general a better health. The higher safety score could be related to the fact that the higher educated generally have better health and are therefore less at risk if infected with the virus than the lower educated. (CBS, 2019). The significance of these results will also be computed in paragraph 5.2.4 .

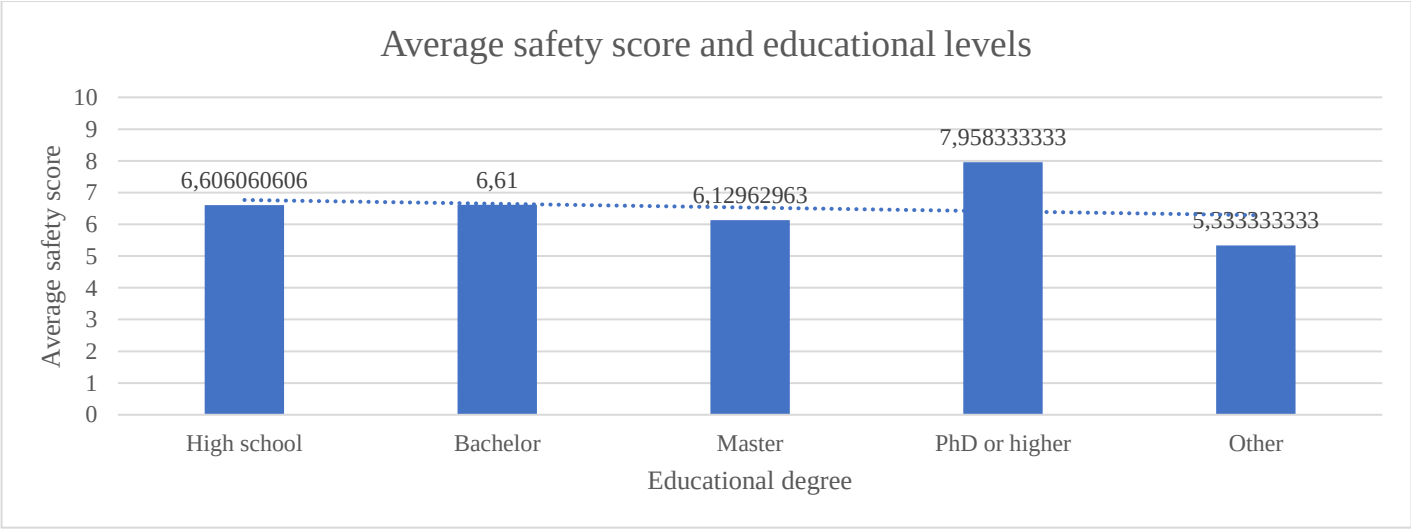

Figure 10: Average safety score of different educational levels.

Relationship between encouragement score and safety score

To find out if there is a relation between the safety score and the encouragement score, the averages from every respondent are calculated. In figure 11 the averages per respondents are shown. The average safety score is 6,67 with a standard deviation of 1.97. The average encouragement score is 7.67 with a standard deviation of 1.52.

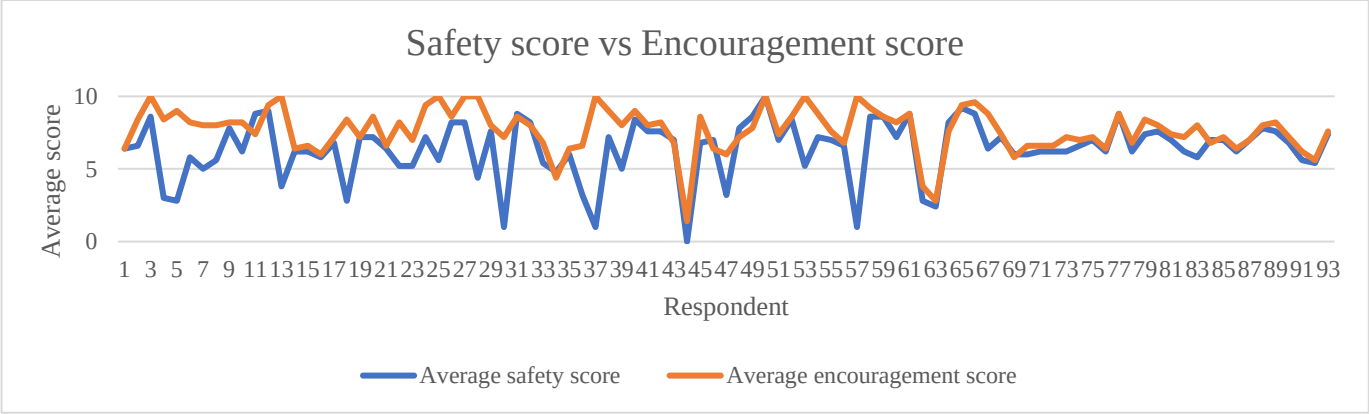

Figure 11 : Average safety score and average encouragement score

The orange line represents the average encouragement score and the blue line the average safety score. On average the relationship between the two scores are similar. When the respondent feels safe, they are encouraged to use public transport. A statistical test is done in the next part of this chapter to see if this relationship is significant.

Usage frequency and transportation mode choice

Usage frequency of public transport before and during the COVID-19 pandemic is shown in figure 10.

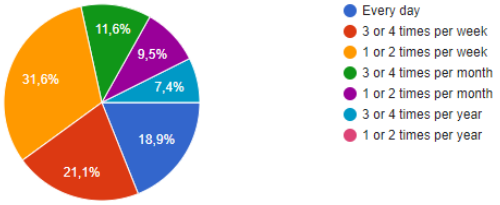

Figure 12: Usage frequency of public transport before the COVID-19 pandemic.

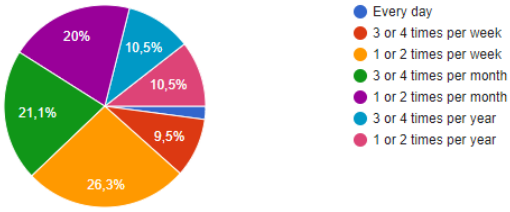

Figure 13: Usage frequency of public transport during (Below) the COVID-19 pandemic.

As can be seen in the chart above the usage is decreased. For example, the blue section of the pie chart is decreased. Before the COVID-19 pandemic 18.9% of the respondents used public transport on a daily basis. During the COVID-19 pandemic this percentage has decreased to 1.4%. The data visualized in figure 12 and figure 13, will be used to test hypothesis 1: *'The usage frequency of public transportation is not different during a pandemic'.*

56 respondents have a motorized vehicle and 37 respondents do not own a motorized vehicle. To investigate if the usage frequency of public transport during a pandemic is influenced by the ownership of motorized vehicles.

Table 5: Usage frequency of public transport of respondents who own a motorized transportation vehicle and respondent who do not own a motorized vehicle

Transport vehicle	Uses public transport more	Uses public transport with the same frequency	Uses public transport less	Total
Motorized	0	7	49	56
Not motorized	0	10	27	37

The data that is presented in table 5 is used to test hypothesis 2: '*People, who are in the possession of a motorized vehicle, are less likely to use public transportation during the pandemic then people who don't own a motorized vehicle or a bicycle'.*

An interesting results regarding the transportation mode choice is that 63,7% of the respondents are using the car more during a pandemic and 52,7% of the respondent are using the bicycle more during the pandemic.

Scenario results

The average from the safety and encouragement scores are shown in figure 14 and 15.

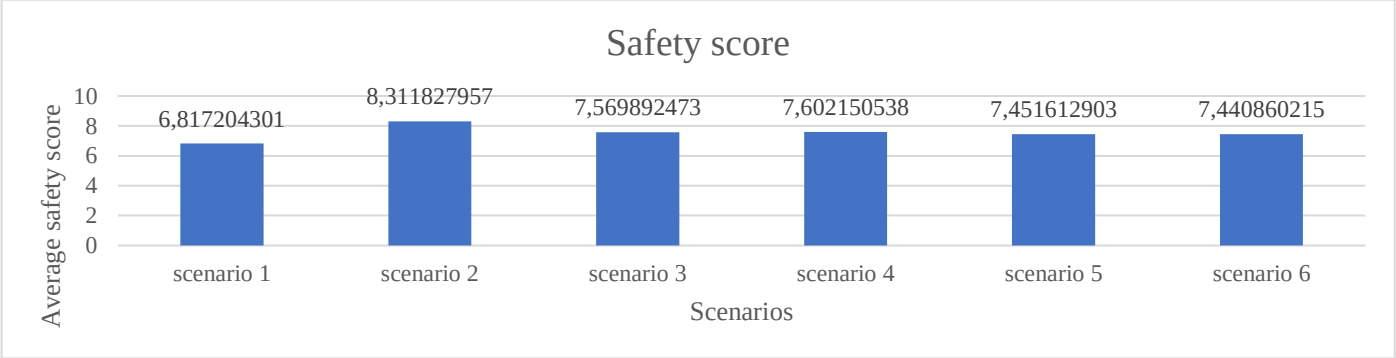

Figure 14: Average safety score of every scenario

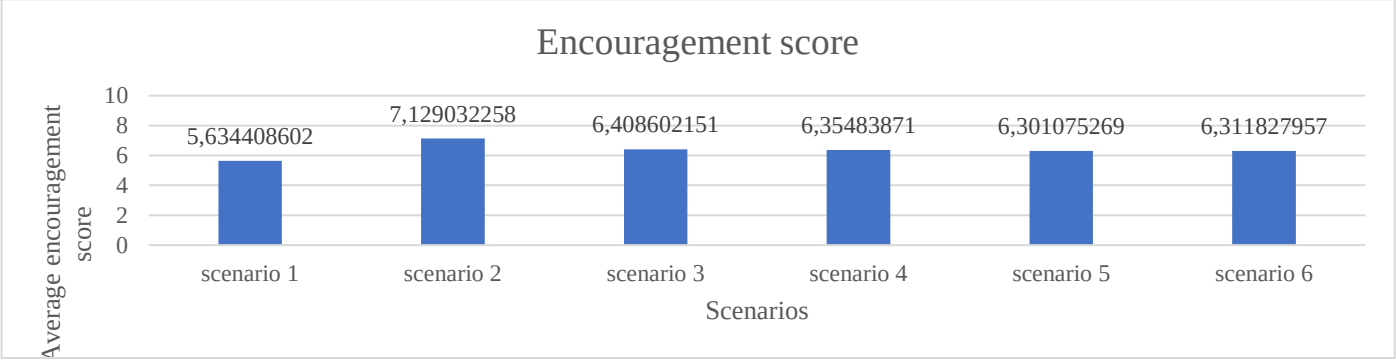

Figure 15: Average encouragement score of every scenario

The scenarios 2-5 all have a higher safety and encouragement score than the current situation (scenario 1: wearing a face mask and keeping distance). This shows that the created safety measures (scenario 2-5) are improving the feeling of safety and encourage people to use public transportation more than in the currently used safety measures.

5.2 Analyzing the results

To show that the observations from chapter 5.2 are significant several statistical test are computed. These statistical tests are needed to reject or retain the null hypothesis from chapter 1. The tests that are used are the Wilcoxon signed rank test, Mann-Whitney U test, Spearman correlation and the Kruskall-wallis H test. For the tests, a critical p-value of 0.05 is used. This means that the probability of that a relationship between two variables due to error, is 5 in 100. If the computed significance level is below this critical value, the null hypothesis is rejected. An overview of the hypotheses and the statistical tests that are used, are given in paragraph 3.1.2. .

5.2.1 Wilcoxon signed rank test

The Wilcoxon signed rank test is used to determine if the usage frequency of public transport is decreased significantly during a pandemic (hypothesis 1) and to determine which scenario gives a better safety or encouragement score than the current situation (hypothesis 5 & 6) .

Hypothesis 1

The first hypothesis is used to determine if the usage frequency of public transport is different during a pandemic. The null-hypothesis is '*The usage frequency of public transportation is not different during a pandemic'*. The usage frequency of public transport before and during the pandemic is calculated from the results of the respondents are calculated. The Wilcoxon signed rank test has a computed significance level that is smaller than the critical p-value of 0.05. This shows that the first null-hypothesis can be rejected and that there is a significant difference between usage frequency of public transport before and during a pandemic. From the test it can be concluded that the usage frequency of public transport has significantly decreased because of the pandemic. The additional question from the survey shows that this decrease is mainly because people are concerned about their health (fear of getting contaminated with the virus) and that they need to travel less.

Hypothesis 5

Hypothesis 5 is used to determine if scenario 2-5 encourage people to use public transport more than the current situation (scenario 1). To determine if the difference between the encouragement scores are significant the scores from every scenario are compared to encouragement score of the current situation. The test shows that scenario 2 and 3 have a significance different encouragement score than scenario 1. The test also shows that scenario 2 (fewer passengers in transport vehicle) and 3 (hand sanitizing is obliged) have a significant higher encouragement score than scenario 1 and that scenario 2 encourages the respondents the most to use public transport. An overview of the rejected and retained hypotheses is given in the table 6 on the next page.

Table 6: Results of the Wilcoxon signed rank test for hypothesis 5

Null- Hypothesis	Null hypothesis rejected or retained
There is no difference between the encouragement score of scenario 1 (current situation) and that of scenario 2 (Increased frequency)	Null is rejected
There is no difference between the encouragement score of scenario 1 (current situation) and that of scenario 3 (Hand sanitizing is obliged).	Null is rejected
There is no difference between the encouragement score of scenario 1 (current situation) and that of scenario 4 (protective screens)	Null is retained
There is no difference between the encouragement score of scenario 1 (current situation) and that of scenario 5 (Real-time update through an app)	Null is retained
There is no difference between the encouragement score of scenario 1 (current situation) and that of scenario 6 (Frequent cleaning)	Null is retained

Hypothesis 6

Hypothesis 6 is used to determine if scenario 2-5 makes people feel safer in public transport in comparison to the current situation (scenario 1). Similar to the methodology of hypothesis 5, the safety scores from every scenario are compared to the current situation. The tests show that scenario 2 (Decrease of number of passengers in one vehicle), scenario 3 (Hand sanitizing is obliged) and scenario 4 (Installation of protective screens) have a significant different safety score compared to scenario 1 (Current situation). Similar to hypothesis 5, scenario 2 makes the passengers feel the safest. An overview of the rejected or retained hypotheses from hypothesis 6 are given in table 7.

Table 7: Results of the Wilcoxon signed rank test for hypothesis 6

Null- Hypothesis	Null hypothesis rejected or retained
There is no difference between the safety score of scenario 1 (current situation) and that of scenario 2 (Increased frequency)	Null is rejected
There is no difference between the safety score of scenario 1 (current situation) and that of scenario 3 (Hand sanitizing is obliged).	Null is rejected
There is no difference between the safety score of scenario 1 (current situation) and that of scenario 4 (protective screens)	Null is rejected
There is no difference between the safety score of scenario 1 (current situation) and that of scenario 5 (Real-time update through an app)	Null is retained
There is no difference between the safety score of scenario 1 (current situation) and that of scenario 6 (Frequent cleaning)	Null is retained

5.2.2 Mann-Whitney U test

The Mann-Whitney U test is used to investigate the effect that the ownership of a motorized vehicle has an influence in the transport frequency of public transport during a pandemic (hypothesis 2). The computed significance level in higher than the critical value. This shows that there is no significant difference between the usage frequency of public transport of the respondents who own a motorized vehicle and the respondents who do not own a motorized vehicle. In the literature review, the research of Toa mentions that people who own a motorized vehicle tend to use public transportation less often. This is in contrary to the results from the Mann-Whitney U test. In the survey, there were many respondents who have a car and few respondents who do not have a car. The contradiction between the results of this study and Toa's study may be due to the fact that the respondents of this study were not diverse enough.

5.2.3 Spearman-correlation

The relationship between the safety score and encouragement score is analyzed using the spearman-correlation (hypothesis 3). It is of interest to know that there is a relationship between the two scores because the goal of the safety measurements is to encourage people to use public transport during a pandemic. The spearman-correlation test shows that there is a positive (moderate) linear relationship between the safety and encouragement score. This means that if respondents feel safe, they feel more encouraged to use public transportation. This is an important conclusion for public transport planners because they want to encourage people to use public transport. It is now proven that by increasing the feeling of safety, people are more encouraged to use public transportation.

5.2.4 Kruskal-Wallis test

The Kruskal-Wallis test is used to determine if the educational level and the age of the respondent has a significant effect on the average safety score that the respondents gives to the six scenarios (hypothesis 4). The Kruskal-Wallis test shows that age has a significant impact on the average safety scores and educational levels do not have a significant impact on safety scores. In figure 14 is clear to see that the average safety score is lower in the older age groups. Public transport planners can use this information to focus in their strategy against COVID-19 more on elderly people because this result shows that they feel the least safe.

5.3 Summary

The collected data contains of 92 completed surveys. The majority of the respondents are students who do not own a car and are dependent on public transport in their daily life. They survey is distributed with great effort to ensure that respondents of all the different demographic groups are present in the data. The analysis shows that the respondents are less encouraged to use public transport during a pandemic. The respondents indicate that this is mainly caused by the fact that they are scared of getting infected, social distancing and that they need to travel less. The age and the educational level of the respondent have an influence on the given safety scores. Older respondents give in general a lower safety score to the scenarios and higher educated people give a higher safety score. Respondents who own a motorized vehicle are less encouraged to use public transport during a pandemic than respondents who do not own a motorized vehicle. There is a moderate relationship between the safety and encouragement score. Scenario 2 and 3 encourage the respondents the most to use public transport and scenario 2,3 and 4 make the respondent feel the safest. An overview of all the hypothesis is given in table 8.

Table 8: Overview of results of the statistical tests for all the hypotheses

Hypothesis	Conclusion
H1.0: ***The usage frequency of public transportation is not different during a pandemic***	The usage frequency of public transport decreases during a pandemic
H2.0: ***People, who are in the possession of a motorized vehicle, are less likely to use public transportation during the pandemic then people who don't own a motorized vehicle or a bicycle.***	There is no statistical significance in encouragement scores between people who own motorized vehicles and people who do not own motorized vehicles
H3.0 ***There is no relationship between safety score and encouragement score***	There is a positive moderate relationship between the safety and encouragement score
H4.0 A: ***There is no difference in general safety score between educational levels.*** **H4.0 B:** ***There is no difference in general safety score between age groups***	There is no difference in the given safety score between education levels. Older people give in general a lower safety score
H5.0: ***There is no difference in the encouragement score between the current situation and scenarios #***	Scenario 2 (Fewer people in transport vehicles) and scenario 3 (hand sanitizing is obliged) encourages usage of public transport the most.
H6.0: ***There is no difference in the safety score between the current situation and scenario #.***	Scenario 2 (Fewer people in transport vehicles), scenario 3 (hand sanitizing is obliged) and scenario 4 (installation of protective screens) make people feel the safest

6 Discussion

In this chapter the results and the used methodology will be discussed. Section 6.1 an evaluation of the research and the response is made. The limitations of the research and of the survey are discussed and in part 6.2 a proposal is made based on the results on how the public planners of a tram network could adjust their strategy against the COVID-19 pandemic to make passengers feel more safe and more encouraged to use public transportation.

6.1Evaluation of the research and the responses

To research the effect that the COVID-19 pandemic has on the perception of safety, on the usage frequency and on transportation mode choice is a difficult tasks. There are a lot of influential factors. The research cannot analyze all the influential factors and that is why in this research, a selection is made to make the scope of the research smaller. Further research could implement more influential factors.

The scenarios that are created, presented possible safety measures that could be used in public transportation. The used safety measures were based on the results of research done by the Learning platform. However, these are not the only possible safety measures that could be implemented. Further research should also look at other safety measures that could be implemented.

Limiting the number of passengers in a transportation vehicle by increasing the frequency of the transportation network (scenario 2) had the highest safety and encouragements scores. The implementation of this scenario is not very realistic. Due to the effects of the COVID-19 pandemic, the revenues of public transportation have decreased significantly and that is the reason why public transport planners are focusing on reducing the operational cost of public transport. In this scenario the frequency of the transport network increases. The increase will lead to more operational costs and this is not in line with the current strategy of public transport planners. To make this scenario more realistic, cost should have been taking into account. Scenario 2 should be changed to: The number of passengers in a transport vehicle are limited but the price of using public transport service is increased. This would have been a more realistic scenario.

To find an answer to the research question, a survey has been done. The respondents were from different age groups and educational levels but the distribution between the different groups were not equal. This can lead to false conclusion and a false representation of the general population. Due to the COVID-19 pandemic the survey had to be distributed online and this led to a lot of younger respondents. To improve the distribution between the different age groups, the survey was delivered to several retirement homes. The residents could scan a QR-code that brought them to the survey. This increased number of older respondents slightly. To improve the distribution of the educational groups, the survey was sent in different university and college chat groups. This led to a more evenly distributions between the different educational levels.

Incomplete questionnaires are treated as defective data sets and were left out of the survey. This is done to reduce the amount of possible errors in the analysis. The removal was done to ensure that the incomplete data would not lead to incorrect conclusions. Some respondents said that the survey was long, and this could be one of the reasons that not every respondent answered every question. Multiple imputation could have been used to predict the incomplete data sets. Multiple imputation would have reduced the bias in the analysis and improve the validity of the research, but this is not done in this research. In the first version of the survey, there was not a clear definition of the perception of safety. In the second version of the survey, this definition was added. The first survey had 33 respondents and the second version had 68 respondents. The collected data from the two surveys were compared and the comparison showed that by adding the definition, the safety scores were not significantly different. But it would have been clearer to all respondents if they had been given a clear definition at the start of the survey.

6.2 Design proposal for the tram network

To combat the COVID-19 virus, public transport planners and the government have created several general safety measures. The current safety measures that are applied are face mask are mandatory on stations and in transport vehicles and passengers need to keep their distances. In most trams, the driver's cab has been fitted with protective screens and in some station's disinfection dispensers are installed. The results from the survey show that the current situation doesn't make people feel safe and people aren't encouraged to use public transport. Figure 13 and 14 show that every scenario has a higher safety score and encouragement score than the current situation. Statistical test have shown that the change increase of average scores for scenario 2 (limiting the amount of passengers in a transport vehicle), scenario 3 (hand sanitizing is obligatory when entering and leaving a transport vehicle) and scenario 4 (installation of protective screen between passengers seats) are statistical significant. A recommendation for the transport planners would be to instal protective screens between the passenger's seats and instal disinfection dispenser in transport vehicles. These measures make passengers feel significantly safer and more encouraged to use public transport during a pandemic. Limiting the number of passengers (Scenario 2) could also be a solution for increasing the perception of safety and encouragement of passengers but some adjustments should be made (see paragraph 6.1 for the explanation of the adjustments).

7 Conclusion

The research aims to get more insight on the change that the COVID-19 pandemic had on mode choice, usage frequency of public transport and the perception of safety during a pandemic. Furthermore, the research analyzes the effect of several safety measures on the encouragement and safety score of passengers are analyzed. The results of the aforementioned analyzes together form the answer to the research question.

The results of this research show that people are using public transport less during a pandemic because of the restrictions and because they fear getting contaminated. The Wilcoxon signed rank test is used to determine that the change in usage frequency of public transport is decreased significantly. The usages of other modes of transportations had increased significantly during a pandemic, namely: car and bicycle. The feeling of safety is moderated related to the level of encouragement regarding public transportation. This relationship is statistically proven with the Spearman-correlation test. The Kruskal-Wallis test showed that older respondents give in general a lower safety score than younger respondents. Six different scenarios where created and analysis. To find out what public transport planners can do to make passengers feel safer and how people can be encouraged to use public transportation during a pandemic, 5 different safety measures were analyzed. The Wilcoxon signed rank test showed with statistical significance that the current applied safety measures (scenario 1: wearing a face mask is obligatory and social distancing) have in general the worst scores regarding feeling safe and feeling encouraged to use public transport. This result shows that the public transport planners should improve their current strategy if they want to encourage passenger to use public transport during a pandemic. Out of the 5 possible safety measures, limiting the number of passengers in a transport vehicle contribute the most to the feeling of safety and encourages people the most to use public transportation however this measure is not very realistic. Installing disinfection spray and protective screens are safety measures that make also make a significant improvement on the encouragement and perception of safety of passengers and these safety measures can be used by public transport planners to make commuters feel safer when using the public tram network in the Netherlands.

Based on the results, it can be concluded that the COVID-19 pandemic has not only changed how people use public transport but also how they feel when using it. Currently public transport planners are implementing several safety measures to make passengers feel safer. This investigation has shown in what way these strategies can be improved to make people feel safer and more encouraged to use public transport during a pandemic.

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Appendix B : Survey Questions

B1. Survey questions

This definition of perception of safety was not present in the first version of the survey. The definition is given below:

The survey is divided into 4 different parts.

Part 1: Questions based on the personal information of the respondents:

Q1. Age of the respondent?

- 0-17
- 18-24
- 25-29
- 30-39
- 40-49
- 50-59
- 60-69
- 70-79
- 80+

Q2. What is your educational degree

- High School
- Bachelor Degree
- Master's Degree
- PhD or higher
- Other

Q3. What is your profession?

- Student
- Employed
- Unemployed
- Other:

Q4. Are you an essential worker?

- Yes
- No

Q5. Which transport vehicle do you have at your disposal? (multiple answers are possible)

- Car
- Bicycle
- Motorbike
- None of the above

Part 2: Questions based on the transport behaviour **before** the COVID-19 pandemic

Q1. Prior to the COVID-19 pandemic, what mode of transportation did you use on a daily basis? (multiple answers are possible)

- Private car
- Bicycle
- Bus
- Metro
- Train
- Walking
- Other:

Q2. Were you dependent on public transport in your daily life ?

- Yes
- No

Q3. When traveling with public transport, what is your main destination? (multiple answers are possible)

- University
- Work
- Shopping
- Local leisure travel
- Other:

Q4. How often did you use public transportation?

- Every day
- 1 or 2 times per week
- 3 or 4 times per week
- 1 or 2 times per month
- 3 or 4 times per month
- 1 or 2 times per year
- 3 or 4 times per year

Q5. I felt encouraged to use public transport.

- 1 (strongly disagree) – 10 strongly agree

Part 3: Questions based on the transport behaviour **during** the COVID-19 pandemic

Q1. During the pandemic, I felt encouraged to use public transport.

- 1 (strongly disagree) – 10 strongly agree

Q2. During the COVID-19 pandemic, what mode of transportation are you using on a daily basis? (multiple answers are possible)

- Car
- Bicycle
- Bus
- Metro
- Train
- Walking
- motorbike

Q3. Do you use public transportation modes more or less during the COVID-19 pandemic

- More
- Less
- Same

Q4. If you have answered less in the question above, what are the main reasons for this change in transportation behaviour with public transport? (multiple answers are possible)

- Infection concern
- You have to travel less
- Social distance
- Travel time saving
- Cost

Q5. How often do you use public transportation?

- Every day
- 1 or 2 times per week
- 3 or 4 times per week
- 1 or 2 times per month
- 3 or 4 times per month
- 1 or 2 times per year
- 3 or 4 times per year

Q6. Which mode of transportation are you using more during the COVID-19 pandemic? (multiple answers are possible)

- Car
- Bicycle
- Bus
- Metro
- Train
- Motor bike
- Walking
- Other:

Part 4: Questions based on the safety perception regarding safety measures.
Q1.

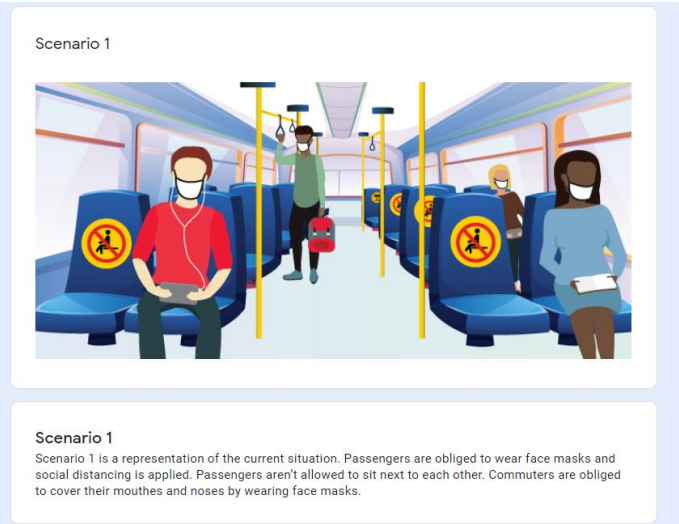

Figure 16 Survey questions scenario 1

Q2.

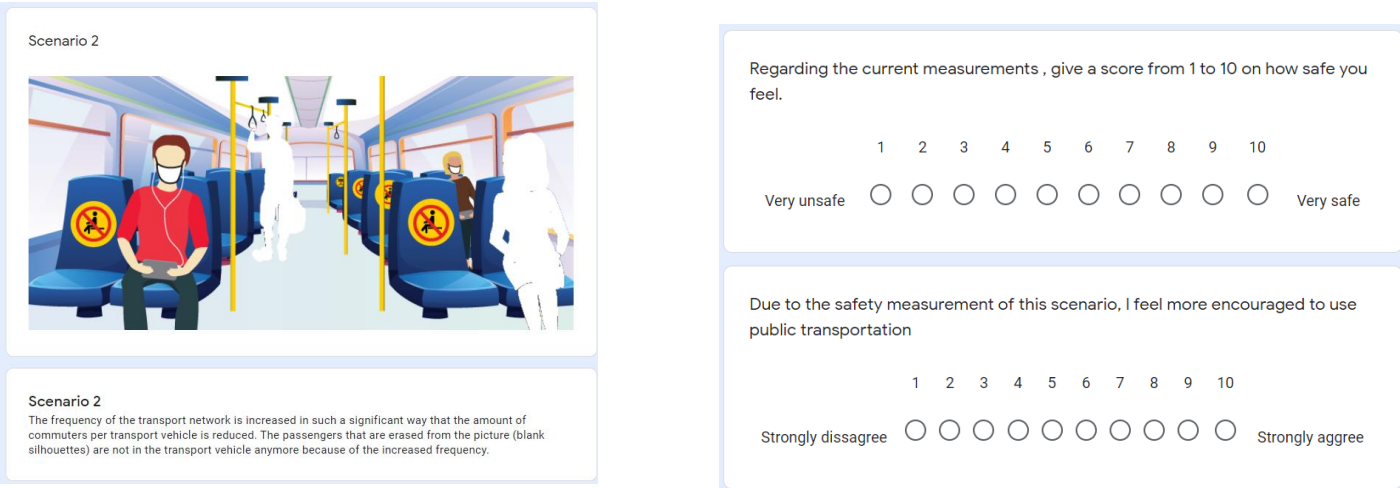

Figure 17 Survey questions scenario 2

Q3

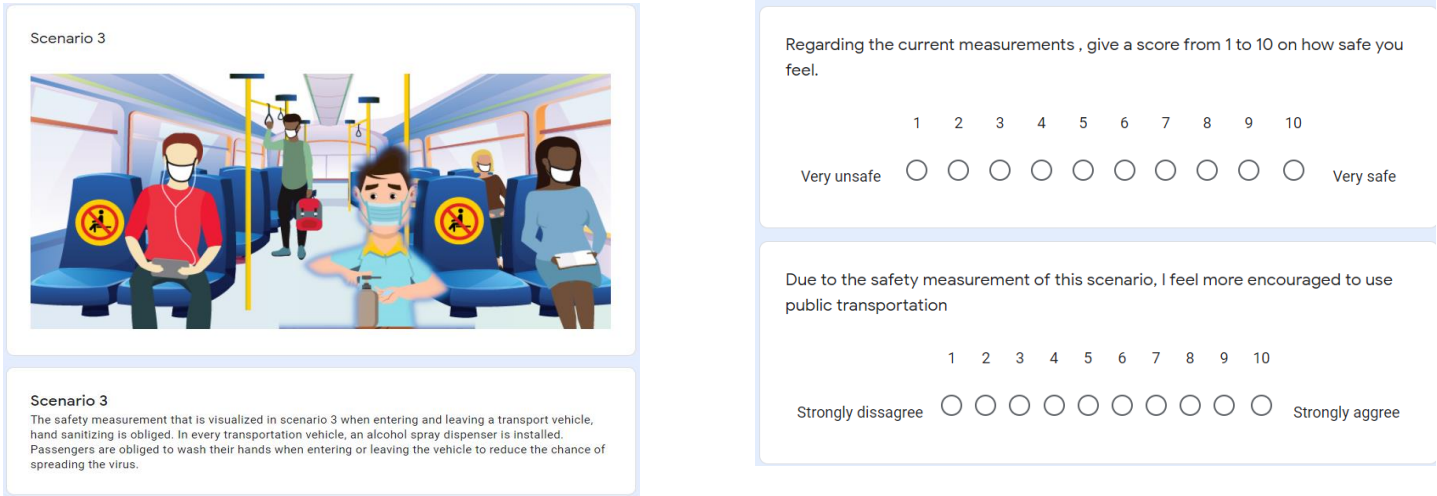

Figure 18 Survey questions scenario 3

Q4

Scenario 4

Scenario 4
The safety measurement that is applied in scenario 4 is the installation of protective screens. Between every passenger protective screen will be placed to reduce the chance of getting infected.

Regarding the current measurements , give a score from 1 to 10 on how safe you feel.

	1	2	3	4	5	6	7	8	9	10	
Very unsafe	○	○	○	○	○	○	○	○	○	○	Very safe

Due to the safety measurement of this scenario, I feel more encouraged to use public transportation

	1	2	3	4	5	6	7	8	9	10	
Strongly dissagree	○	○	○	○	○	○	○	○	○	○	Strongly aggree

Figure 19 Survey questions scenario 4

Q5

Scenario 5

Scenario 5
In this scenario, an app is created by the transportation operators that shows how many passengers there are in the transportation vehicle and how many seats are still available. This way the passengers can choose if he wants to travel with public transport based on real-time data.

Regarding the current measurements , give a score from 1 to 10 on how safe you feel.

	1	2	3	4	5	6	7	8	9	10	
Very unsafe	○	○	○	○	○	○	○	○	○	○	Very safe

Due to the safety measurement of this scenario, I feel more encouraged to use public transportation

	1	2	3	4	5	6	7	8	9	10	
Strongly dissagree	○	○	○	○	○	○	○	○	○	○	Strongly aggree

Figure 20 Survey questions scenario 5

Q6

Scenario 6

Scenario 6
The safety measurement that is applied in this scenario is the following: In every transportation vehicle a member of the cleaning staff is placed. They clean the used surfaces and they clean the newly available seat when someone leaves the transportation vehicle.

Regarding the current measurements , give a score from 1 to 10 on how safe you feel.

	1	2	3	4	5	6	7	8	9	10	
Very unsafe	○	○	○	○	○	○	○	○	○	○	Very safe

Due to the safety measurement of this scenario, I feel more encouraged to use public transportation

	1	2	3	4	5	6	7	8	9	10	
Strongly dissagree	○	○	○	○	○	○	○	○	○	○	Strongly aggree

Figure 21 Survey questions scenario 6

B2. Survey link

https://docs.google.com/forms/d/e/1FAIpQLSenu5BWyPVaS_3U2BBWQPhvRxN47ltDBjqAPFe_swfM8mGCzQ/viewform

Appendix C: Statistical tests

An overview of all the hypotheses with their statistical test are given below.

Wilcoxon ranked signed test

(hypothesis 1)

- H1.0: The usage frequency of public transportation is not different during a pandemic.
- H1.1: The usage frequency of public transportation is different.

(hypothesis 5+6)

- H5.0: There is no difference in the encouragement score between the current situation and scenarios #.
- H6.0: There is no difference in the safety score between the current situation and scenario #.
- H5.1/6.1: scenario 1 has a different (encouragement/safety) score that scenario 2 (Increased frequency).
- H5.2/6.2: scenario 1 has a different (encouragement/safety) score that scenario 3 (Hand sanitizing is obliged).
- H5.3/6.3: scenario 1 has a different (encouragement/safety) score that scenario 4 (Protective screen).
- H5.4/6.4: scenario 1 has a different (encouragement/safety) score that scenario 5 (Real-time update through an app).
- H5.5/6.5: scenario 1 has a different (encouragement/safety) score that scenario 6(Frequent cleaning).

Spearman-correlation:

(hypothesis 3)

- H3.0 There is no relationship between safety score and encouragement score.
- H3.1 There is a relationship between safety score and encouragement score.

Mann-Whitney U test

(hypothesis 2)

- H2.0: People, who are in the possession of a motorized vehicle, are less likely to use public transportation during the pandemic than people who don't own a motorized vehicle or a bicycle.
- H2.1 : There is no difference in the usage frequency of people who do and do not own a motorized vehicle or bicycle.

Kruskal-Wallis

(hypothesis 4)

- H4.0 A: There is no difference in general safety score between educational levels.
- H4.0 B: There is no difference in general safety score between age groups.
- H4.1 A: People with different educational levels give in general a different safety score
- H4.1 B: Older people give a different safety score.

The critical p-value that is used to test the hypothesis is 0.05

Hypothesis 1 **(Wilcoxon signed rank test)**

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between PreCOVID and DurCOVID equals 0.	Related-Samples Sign Test	,000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is ,050.

Related-Samples Sign Test Summary

Total N	97
Test Statistic	1,000
Standard Error	3,841
Standardized Test Statistic	-7,291
Asymptotic Sig.(2-sided test)	,000

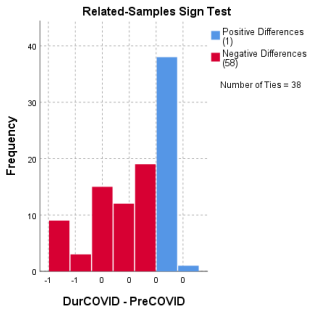

Figure 22 Wilcoxon signed rank test results for hypothesis 1 (SPSS)

The computed significance level is 0.000 and this below the critical p-value, this means that the null hypothesis is rejected. This means that there is a significant difference between the usage frequency of public transport before and during the COVID-19 pandemic.

Hypothesis 2 **(Mann-Whitney U test)**

Ranks

	Vehicle	N	Mean Rank	Sum of Ranks
Average_Encouragement_Score	1,00	56	43,58	2440,50
	2,00	37	52,18	1930,50
	Total	93		

Test Statistics[a]

	Average_Encouragement_Score
Mann-Whitney U	844,500
Wilcoxon W	2440,500
Z	-1,506
Asymp. Sig. (2-tailed)	,132

a. Grouping Variable: Vehicle

Figure 23 Mann-Whitney U test results for hypothesis 2 (SPSS)

Vehicle 1 = respondent owns a motorized vehicle, vehicle 2 = respondent don't own a motorized vehicle.

The computed significance level is 0,132 and this is above the critical p-value, this means that the null hypothesis is retained. The statistical test shows that there is no significant difference in the encouragement level between people who own a motorized vehicle and people who do not own a motorized vehicle.

Hypothesis 3 **(Spearman-correlation test)**

Table 7 : Results from the Spearman correlation test for hypothesis 3.

Correlations

		Safety_Score	Encouragement_Score
Safety_Score	Pearson Correlation	1	,367**
	Sig. (2-tailed)		,000
	N	93	93
Encouragement_Score	Pearson Correlation	,367**	1
	Sig. (2-tailed)	,000	
	N	93	93

**. Correlation is significant at the 0.01 level (2-tailed).

Spearman ρ	Correlation
≥0.70	Very strong relationship
0.40-0.69	Strong relationship
0.30-0.39	Moderate relationship
0.20-0.29	Weak relationship
0.01-0.19	No or negligible relationship

This descriptor applies to both positive and negative relationships.
(Adapted From Dancey and Reidy, 2004)[40]

Figure 24 Spearman correlation test results for hypothesis 3 (SPSS) + correlation table

The possible correlation between the safety score and the encouragement score is tested with the Spearman correlation. The results of the test are presented in figure 24. The computed significance level is 0.008. This is lower than the critical significance level and this means that the correlation between safety score and encouragement score is statistically significant. The computed correlation coefficient that is calculated is with the Spearman correlation test is equal to 0.314. The table in figure 24 shows the different relationships depending on the correlation coefficient. The table shows that with a spearman correlation coefficient of 0,367, that there is a positive moderate relationship between the safety and encouragement score.

Hypothesis 4a **(Kruskal-Wallis test)**

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Safety_score is the same across categories of Educational_level.	Independent-Samples Kruskal-Wallis Test	,740	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is ,050.

Independent-Samples Kruskal-Wallis Test Summary

Total N	93
Test Statistic	1,975[a,b]
Degree Of Freedom	4
Asymptotic Sig.(2-sided test)	,740

a. The test statistic is adjusted for ties.

b. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Figure 25 Kruskal-Wallis test results for hypothesis 4a (SPSS)

The computed significance level is 0,740 and this is above the critical p-value, this means that the null hypothesis is retained. The Kruskal-Wallis test shows that distribution of safety scores is the same across the different categories of education.

Hypothesis 4b Hypothesis 4a **(Kruskal-Wallis test)**

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of safety_score is the same across categories of Age.	Independent-Samples Kruskal-Wallis Test	,006	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is ,050.

Independent-Samples Kruskal-Wallis Test Summary

Total N	93
Test Statistic	16,431[a]
Degree Of Freedom	5
Asymptotic Sig.(2-sided test)	,006

a. The test statistic is adjusted for ties.

Figure 26 Kruskal-Wallis test results for hypothesis 4b (SPSS)

The computed significance level is 0.006 and this below the critical p-value, this means that the null hypothesis is rejected. The Kruskal-Wallis test shows that there is a significant difference in the distribution of safety scores between different age categories.

Hypothesis 5 **(Wilcoxon signed rank test)**

Scenario 2:

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between scenario1b and scenario2b equals 0.	Related-Samples Wilcoxon Signed Rank Test	,000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is ,050.

Scenario1, Scenario2

Related-Samples Wilcoxon Signed Rank Test Summary

Total N	92
Test Statistic	2453,500
Standard Error	172,350
Standardized Test Statistic	6,820
Asymptotic Sig.(2-sided test)	,000

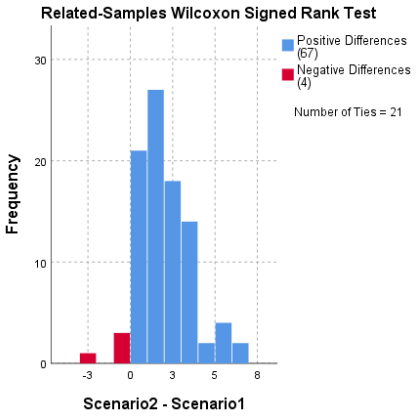

Figure 27 Wilcoxon signed rank test results for hypothesis 5.1 (SPSS)

Hypothesis 5.1: *'There is no difference in the encouragement score between the current situation and scenarios 2 (Increased frequency)' is* statistically tested with the Wilcoxon signed rank test. The computed significance level is lower than the critical significance level and thus hypothesis 5.1 is rejected. This means that there is a significant statistical difference between the encouragement scores of scenario 1 and 2. Figure 27 shows the results from the Wilcoxon signed rank test and shows that the difference between the mean of the encouragement score of scenario 2 and 1. It is clearly visible that scenario 2 has a higher average score than scenario 1. This means that the respondents generally give a higher encouragement score to scenario 2 than to the current situation.

Scenario 3:

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between Scenario1 and Scenario3 equals 0.	Related-Samples Wilcoxon Signed Rank Test	,000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is ,050.

Related-Samples Wilcoxon Signed Rank Test Summary

Total N	92
Test Statistic	1686,500
Standard Error	150,286
Standardized Test Statistic	4,086
Asymptotic Sig.(2-sided test)	,000

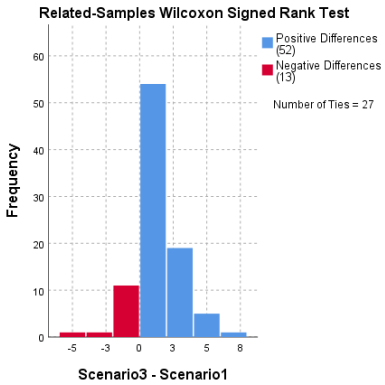

Figure 28 Wilcoxon signed rank test results for hypothesis 5.2 (SPSS)

Hypothesis 5.2: *'There is no difference in the encouragement score between the current situation and scenarios 3(Hand sanitizing is obliged)' is* statistically tested with the Wilcoxon signed rank test. Figure 28 shows the results of the Wilcoxon signed rank test. The computed significance level is lower than the critical significance level and thus hypothesis 5.2 is rejected. This means that there is a significant statistical difference between the encouragement scores of scenario 1 and 3. Figure 28 shows that the difference between the mean of the encouragement score of scenario 3 and 1. It is clearly visible that scenario 3 has a higher average score than scenario 1. This means that the respondents generally give a higher encouragement score to scenario 3 than to the current situation.

Scenario 4:

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between Scenario1 and Scenario4 equals 0.	Related-Samples Wilcoxon Signed Rank Test	,144	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is ,050.

Related-Samples Wilcoxon Signed Rank Test Summary

Total N	92
Test Statistic	1147,500
Standard Error	138,147
Standardized Test Statistic	1,462
Asymptotic Sig.(2-sided test)	,144

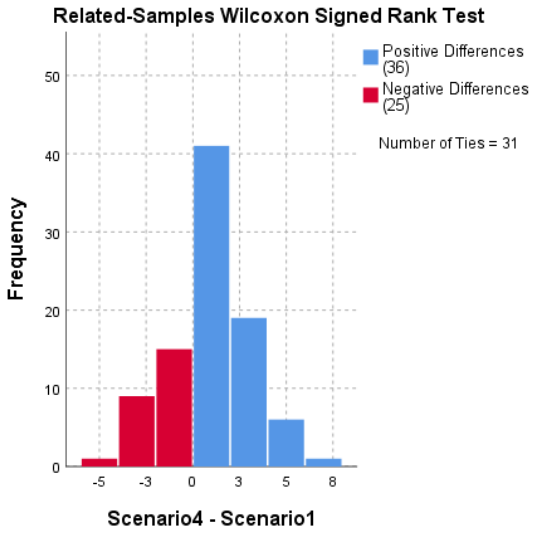

Figure 29 Wilcoxon signed rank test results for hypothesis 5.3 (SPSS)

Hypothesis 5.3: *'There is no difference in the encouragement score between the current situation and scenarios 4* (Protective screen)' *is* statistically tested with the Wilcoxon signed rank test. Figure 29 shows the results of the Wilcoxon signed rank test. The computed significance level is greater than the critical significance level and thus hypothesis 5.3 is retained. This means that there is not a significant statistical difference between the encouragement scores of scenario 1 and 4.

Scenario 5:

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between Scenario1 and Scenario5 equals 0.	Related-Samples Wilcoxon Signed Rank Test	,132	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is ,050.

Related-Samples Wilcoxon Signed Rank Test Summary

Total N	92
Test Statistic	1153,000
Standard Error	137,934
Standardized Test Statistic	1,504
Asymptotic Sig.(2-sided test)	,132

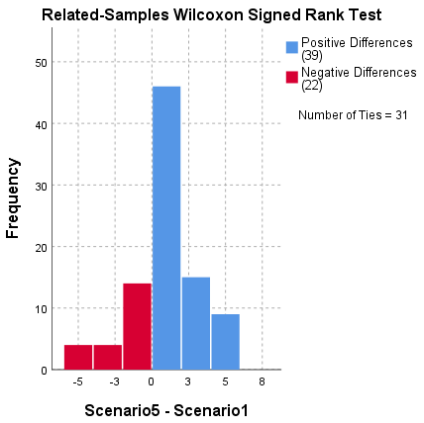

Figure 30 Wilcoxon signed rank test results for hypothesis 5.4 (SPSS)

Hypothesis 5.4: *'There is no difference in the encouragement score between the current situation and scenarios 5 (Real-time update through an app)'* *is* statistically tested with the Wilcoxon signed rank test. Figure 30 shows the results of the Wilcoxon signed rank test. The computed significance level is greater than the critical significance level and thus hypothesis 5.4 is retained. This means that there is not a significant statistical difference between the encouragement scores of scenario 1 and 5.

Scenario 6:

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between Scenario1 and Scenario6 equals 0.	Related-Samples Wilcoxon Signed Rank Test	,088	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is ,050.

Related-Samples Wilcoxon Signed Rank Test Summary

Total N	92
Test Statistic	1407,000
Standard Error	157,244
Standardized Test Statistic	1,704
Asymptotic Sig.(2-sided test)	,088

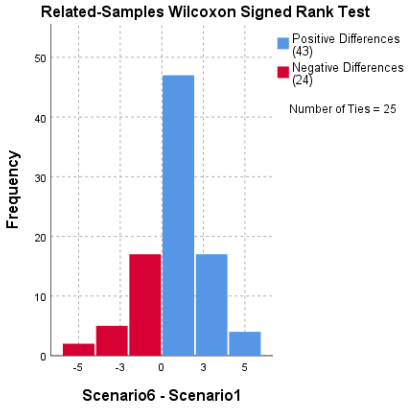

Figure 31 Wilcoxon signed rank test results for hypothesis 5.5 (SPSS)

Hypothesis 5.5: *'There is no difference in the encouragement score between the current situation and scenarios 6 (Frequent cleaning)' is* statistically tested with the Wilcoxon signed rank test. Figure 31 shows the results of the Wilcoxon signed rank test. The computed significance level is greater than the critical significance level and thus hypothesis 5.5 is retained. This means that there is not a significant statistical difference between the encouragement scores of scenario 1 and 6.

Overview of hypothesis 5:

Table 9: Overview of results of the statistical tests for hypothesis 5

Hypothesis	Null hypothesis rejected or retained
Hypothesis 5.1	Null is rejected
Hypothesis 5.2	Null is rejected
Hypothesis 5.3	Null is retained
Hypothesis 5.4	Null is retained
Hypothesis 5.5	Null is retained

The test also shows that scenario 2 (fewer passengers in transport vehicle) and 3 (hand sanitizing is obliged) have a significant higher encouragement score than scenario 1 and that scenario 2 encourages the respondents the most to use public transport.

Hypothesis 6 **(Wilcoxon signed rank test)**

Scenario 2:

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between Scenario1 and Scenario2 equals 0.	Related-Samples Wilcoxon Signed Rank Test	,000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is ,050.

Related-Samples Wilcoxon Signed Rank Test Summary

Total N	92
Test Statistic	2563,000
Standard Error	176,054
Standardized Test Statistic	7,094
Asymptotic Sig.(2-sided test)	,000

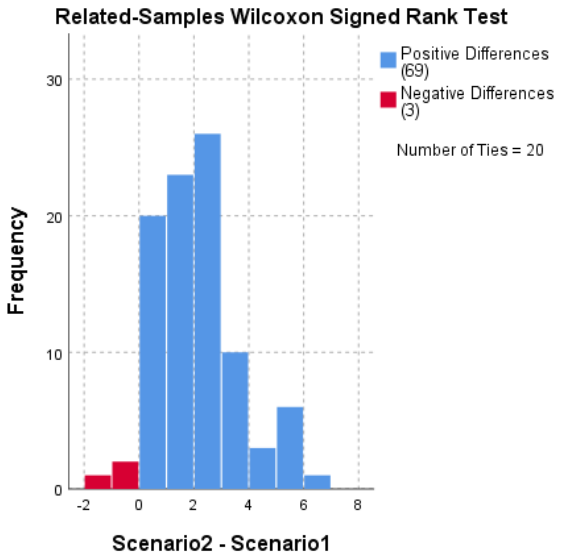

Figure 32 Wilcoxon signed rank test results for hypothesis 6.1 (SPSS)

Hypothesis 6.1: *'There is no difference in the safety score between the current situation and scenarios 2 (Increased frequency)' is* statistically tested with the Wilcoxon signed rank test. Figure 32 shows the results of the Wilcoxon signed rank test. The computed significance level is lower than the critical significance level and thus hypothesis 6.1 is rejected. This means that there is a significant statistical difference between the safety scores of scenario 1 and 2. Figure 22 shows that the difference between the mean of the safety score of scenario 2 and 1. It is clearly visible that scenario 2 has a higher average score than scenario 1. This means that in general, the respondents give a higher encouragement score to scenario 2 than to the current situation.

Scenario 3:

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between Scenario1 and Scenario3 equals 0.	Related-Samples Wilcoxon Signed Rank Test	,000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is ,050.

Related-Samples Wilcoxon Signed Rank Test Summary

Total N	92
Test Statistic	1972,500
Standard Error	167,638
Standardized Test Statistic	4,355
Asymptotic Sig.(2-sided test)	,000

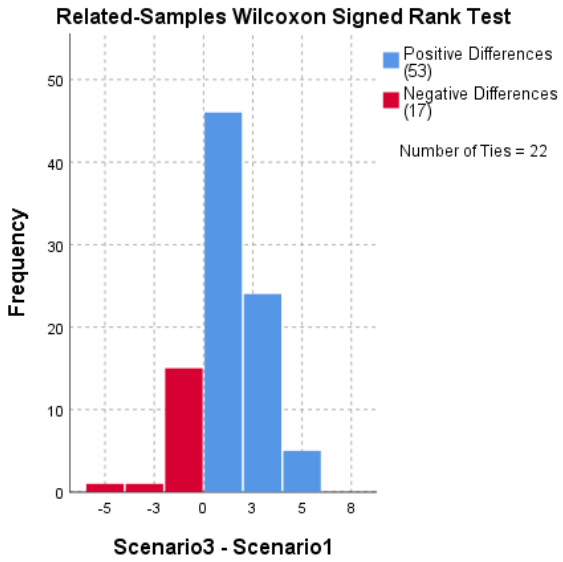

Figure 33 Wilcoxon signed rank test results for hypothesis 6.2 (SPSS)

Hypothesis 6.2: *'There is no difference in the safety score between the current situation and scenarios 3(Hand sanitizing is obliged)' is* statistically tested with the Wilcoxon signed rank test. Figure 33 shows the results of the Wilcoxon signed rank test. The computed significance level is lower than the critical significance level and thus hypothesis 6.2 is rejected and there is a significant statistical difference between the safety scores of scenario 1 and 3. Figure 23 shows that the difference between the mean of the safety score of scenario 3 and 1. It is clearly visible that scenario 3 has a higher average score than scenario 1. This means that in general, the respondents give a higher safety score to scenario 3 than to the current situation.

Scenario 4:

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between Scenario1 and Scenario5 equals 0.	Related-Samples Wilcoxon Signed Rank Test	,000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is ,050.

Related-Samples Wilcoxon Signed Rank Test Summary

Total N	92
Test Statistic	1652,000
Standard Error	154,864
Standardized Test Statistic	3,529
Asymptotic Sig.(2-sided test)	,000

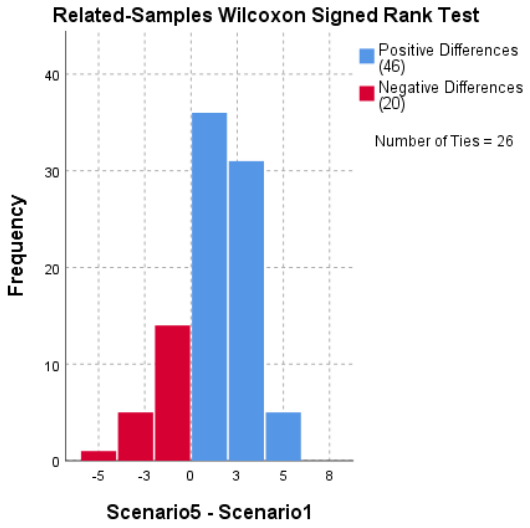

Figure 34 Wilcoxon signed rank test results for hypothesis 6.3 (SPSS)

Hypothesis 6.3: *'There is no difference in the safety score between the current situation and scenarios 4 ((Protective screen)' is* statistically tested with the Wilcoxon signed rank test. Table 15 shows the results of the Wilcoxon signed rank test. The computed significance level is lower than the critical significance level and thus hypothesis 6.3 is rejected and there is a significant statistical difference between the safety scores of scenario 1 and 4. Figure 24 shows that the difference between the mean of the safety score of scenario 4 and 1. It is clearly visible that scenario 4 has a higher average score than scenario 1. This means that in general, the respondents give a higher safety score to scenario 4 than to the current situation.

Scenario 5:

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between Scenario1 and Scenario5 equals 0.	Related-Samples Wilcoxon Signed Rank Test	,098	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is ,050.

Related-Samples Wilcoxon Signed Rank Test Summary

Total N	92
Test Statistic	1067,000
Standard Error	127,988
Standardized Test Statistic	1,652
Asymptotic Sig.(2-sided test)	,098

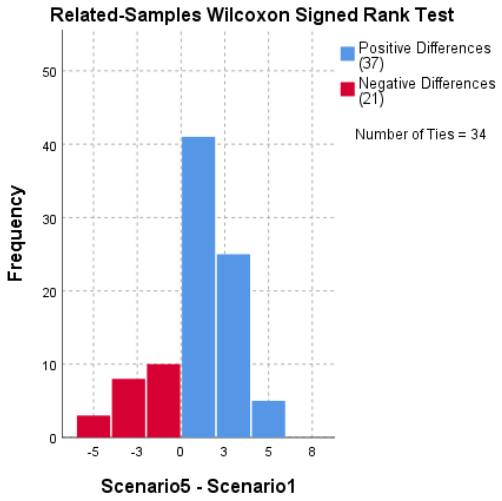

Figure 35 Wilcoxon signed rank test results for hypothesis 6.4 (SPSS)

Hypothesis 6.4: *'There is no difference in the safety score between the current situation and scenarios 5 (Real-time update through an app)' is* statistically tested with the Wilcoxon signed rank test. Figure 35 shows the results of the Wilcoxon signed rank test. The computed significance level is greater than the critical significance level and thus hypothesis 6.4 is retained. This means that there is not a significant statistical difference between the safety scores of scenario 1 and 5.

Scenario 6:

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between Scenario1 and Scenario6 equals 0.	Related-Samples Wilcoxon Signed Rank Test	,222	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is ,050.

Related-Samples Wilcoxon Signed Rank Test Summary

Total N	92
Test Statistic	1149,500
Standard Error	141,517
Standardized Test Statistic	1,222
Asymptotic Sig.(2-sided test)	,222

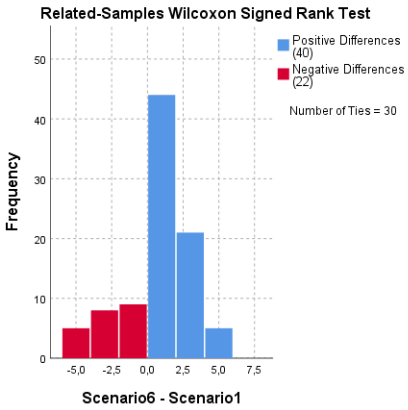

Figure 36 Wilcoxon signed rank test results for hypothesis 6.5 (SPSS)

Hypothesis 6.5: *'There is no difference in the safety score between the current situation and scenarios 6(Frequent cleaning)' is* statistically tested with the Wilcoxon signed rank test. Figure 36 shows the results of the Wilcoxon signed rank test. The computed significance level is greater than the critical significance level and thus hypothesis 6.5 is retained. This means that there is not a significant statistical difference between the safety scores of scenario 1 and 6.

Overview of Hypothesis 6:

Table 10: Overview of results of the statistical tests for hypothesis 6

Hypothesis	Null hypothesis rejected or retained
Hypothesis 6.1	Null is rejected
Hypothesis 6.2	Null is rejected
Hypothesis 6.3	Null is rejected
Hypothesis 6.4	Null is retained
Hypothesis 6.5	Null is retained

The tests show that scenario 2 (Decrease of number of passengers in one vehicle), scenario 3 (Hand sanitizing is obliged) and scenario 4 (Installation of protective screens) have a significant different safety score compared to scenario 1 (Current situation).