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Using Public Opinion to Predict Changes in Transportation Demand during the COVID-19 Pandemic

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ABSTRACT

The purpose of this thesis was to investigate public concerns related to public transportation usage due to the COVID-19 Pandemic. The goal was to gain a better understanding of health and safety concerns of the public for three modes of public transportation; Commuter Rail, Subway/Underground Rail, and Bus, and to use this information to predict public transportation demand in a post- COVID-19 world. A survey of 1,000 United States residents was conducted through Amazon's Mechanical Turk crowdsourcing survey tool to probe public opinion regarding these issues. Data cleaning resulted in a sample size of 520 participants for analysis. The findings of this study is that there is a high level of public concern for public transportation usage since the start of the COVID-19 pandemic. There is a decrease in predicted public transportation ridership after the COVID-19 pandemic according to the survey results. Lastly, there are not large differences in level of concern among demographic sub-groups and there are no strong financial predictors of level of concern.

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Chapter 1: Introduction

In March of 2020, much of the United States began to close down and stay at home orders were issued in response to the World Health Organization's (WHO) declaration of the Coronavirus disease 2019 (COVID-19) as a worldwide pandemic. The widespread shutdown of businesses resulted in plummeting ridership across mass transit systems worldwide. The change in ridership caused significant changes for transportation agencies in major cities across the United States. For example, the Metropolitan Transportation Authority (MTA) in New York City slashed train and bus services as they quickly became the epicenter for the spreading of the virus. In the spring of 2020, the MTA saw historic reductions in ridership of more than 90 percent compared to that time a year earlier. King County Metro in Seattle is projecting more than 600 million dollars in lost revenues through 2022; Philadelphia is expecting upwards of 300 million dollars in lost revenue through mid-2021; and Los Angeles Metro is looking at 1.8 billion dollars in pandemic related losses (Garza, 2020). Similar ridership trends and revenue losses are expected in more cities including Chicago, Baltimore, Washington, D.C., and more. Since there is no clear end to the COVID-19 pandemic, many questions remain regarding the short and long term effects of the corresponding social behaviors on ridership and revenue.

The quick arrival of the disease and the extraordinary behavioral effects in response to this rapid onset have led to unprecedented effects on transportation systems. Because of these circumstances, there is currently very little research about almost every social aspect of this situation. There are critical questions that remain unanswered. Major changes are predicted to what will happen regarding the public's willingness to use public transportation. While many news articles have discussed current implications of the COVID-19 pandemic on the transportation industry, little is known about whether or not the low ridership numbers and high revenue losses will last.

During the spring of 2020 there was a major plunge in public transportation ridership due to closed businesses and stay at home orders. However, as people have started to return to work in person, many have been opting to use their personal vehicles instead of buses, subways, or trains. There may be concerns over the health and safety of shared vehicles related to crowds, sanitization, and rules regarding mask wearing. Many transportation agencies have made changes to their operating schedules and protocols to keep their employees and riders safe. Several agencies have adapted their rules to include mask wearing and social distancing on public transportation vehicles. A number of these operators have also made changes to their service and schedules to account for the decreased ridership and revenue. For example, in New York City, the MTA Essential Service Plan slashed subway service by 25 percent and reduced the schedules of the Metro North and Long Island Rail Road (LIRR) commuter rail services in the spring of 2020. A few researchers have studied the changes in ridership, the revenue losses, and the responses of transportation agencies to this crisis; however, there has been little effort to assess the public's opinions and concerns in regard to public transportation.

The main goal of this study was to understand public opinion regarding their safety concerns about using rail and bus transportation during the COVID-19 pandemic. If more is understood regarding public concerns and transportation agency preferences, then predictions can be made regarding future public transportation demand. These predictions are important for the planning and investment of all transportation modes. The implications of the COVID-19 pandemic will be long lasting, and how the public reacts to the return of "normal" life is important in planning for the possibilities of increased vehicle traffic and decreased public transportation ridership. To achieve the study goals an online survey was planned, designed, administered, and analyzed to understand public opinions and concerns regarding public transportation and the COVID-19 pandemic.

The survey conducted for this thesis sought to answer the following questions:

- How concerned are people about the use of public transportation because of COVID-19?
- What safety procedures will effectively ease any public concern with public rail and bus transportation?
- How likely are people to resume the use of public transportation, or will they seek alternative methods? How will demand for public transportation change?
- How will personal financial situations affect people's decisions about public transportation usage?

The subsequent chapters of this thesis provide a:

- state-of-the-art/state-of-the-practice review (Chapter 2),
- description of the study methods (Chapter 3),
- summary and analysis of the survey data including a series of descriptive statistics, and statistical tests to establish findings about public opinion related to public transportation use (Chapter 4), and
- listing of the conclusions that were reached and some suggestions for additional research in this area (Chapter 5).

Chapter 2: Literature Review

To establish a base of knowledge related to the state-of-the-art and the state-of-the- practice for the topic area, a targeted literature review was conducted to determine past and current practices related to transportation service measures enacted to maintain hygiene and safety during a public health crisis. Particular emphasis was placed on measures employed by public transportation systems or other relevant areas of the common carrier industry. This included cleaning and disinfecting of common surfaces, mask wearing for employees, mask wearing for passengers, and health checks. A brief summary of the relevant findings and practices for each of these areas is discussed below.

Cleaning of Physical Assets

Several studies described the practices used by transit agencies when cleaning transit vehicles and how this has changed since the start of the COVID-19 Pandemic. Many transportation agencies have released information on how they are cleaning to put passengers at ease related to any concerns they may have about contaminated surfaces or heating, ventilating, and air conditioning (HVAC) systems. The (New York City) Metropolitan Transportation
Agency (MTA) released a statement explaining their new cleaning procedures in October 2020. In this statement, it was explained that as of May 6, 2020, the number of cleaners working throughout the night to disinfect common touch points had increased. The buses and trains undergo a more comprehensive cleaning overnight, and more cleaners are seen throughout the day at end-of-line stations. The MTA has also been testing and piloting new technologies to clean and disinfect more efficiently including, antimicrobial biostats, ultraviolet light, electrostatic sprayers, and innovative air filters (MTA, 2020).

The American Public Transportation Association (APTA) studied and released guidance in June of 2020 for transit agencies titled, “Cleaning and Disinfecting Transit Vehicles and Facilities During a Contagious Virus Pandemic”. This study was conducted and the paper written specifically in response to the COVID-19 virus, but this work may be applicable to other pandemic diseases. Cleaning and disinfecting schedules, materials, testing, as well as vehicle/facility design and modifications are outlined in this document (APTA, 2020). As public concern over infection has risen, the development of new technologies to deal with the effects of an epidemic has grown. In response to the 2014 Ebola virus outbreak, sterilizing foggers were created and used to quickly disinfect ambulances between patient uses (“Sterilizing Fogger Cleans Ambulances with a Breeze”, 2018). Although employed primarily for ambulances, such technology has been gaining interest from other agencies and can be implemented in other types of transportation systems.

Mask Wearing by Transit Employees

In response to COVID-19, mask wearing by employees has been required by many transportation agencies across the United States. However, as of February 1, 2021, the Centers for Disease Control (CDC) issued an order that requires the wearing of face masks on conveyances and transportation hubs for both passengers and employees (CDC, 2021). Proper face coverings as well as social distancing has been recommended by the CDC and other agencies; however, this is the first order that requires properly worn masks across the U.S. There is currently no evidence of a direct correlation between the use of public transit and the transmission of COVID-19; however, mask wearing could be a life saving measure.

Mask Wearing by Transit Passengers

The proper usage of masks for all individuals in public settings has been recommended by the CDC since early 2020. Although the CDC mask order in response to President Biden's executive order only began in early January 2021, many agencies have been effectively enforcing mask wearing since 2020. The MTA, serving the greater New York area, gathered a group of 300 employees and volunteers to create a "mask force" in July of 2020. New York City quickly emerged as the epicenter of the virus in 2020 and this "mask force" aimed to encourage the widespread use of masks by handing out free disposable surgical masks to transportation customers throughout subways, buses, and trains (Weaver, 2020). In a survey conducted in early January 2021, there was a 97 percent mask usage among 111,785 subway riders as well as a 99 percent mask usage rate among 64,620 bus riders (MTA, 2021).

Many studies have been conducted to understand the effectiveness of mask wearing in slowing the spread of COVID-19. Since general mask wearing requirements are decided on a state level or even a county level, there are many state leaders who do not require the use of masks in public. A study was conducted by the CDC in Kansas, where mask mandates were in effect on a county by county level. The results showed a decrease in COVID-19 cases in counties where masks were required compared to the counties where they were not mandated (Hubbard, 2021). Figure 1 shows 7-day rolling average of new cases per 100,000 residents for counties with and without the mask mandate both before and after the governor's executive order.

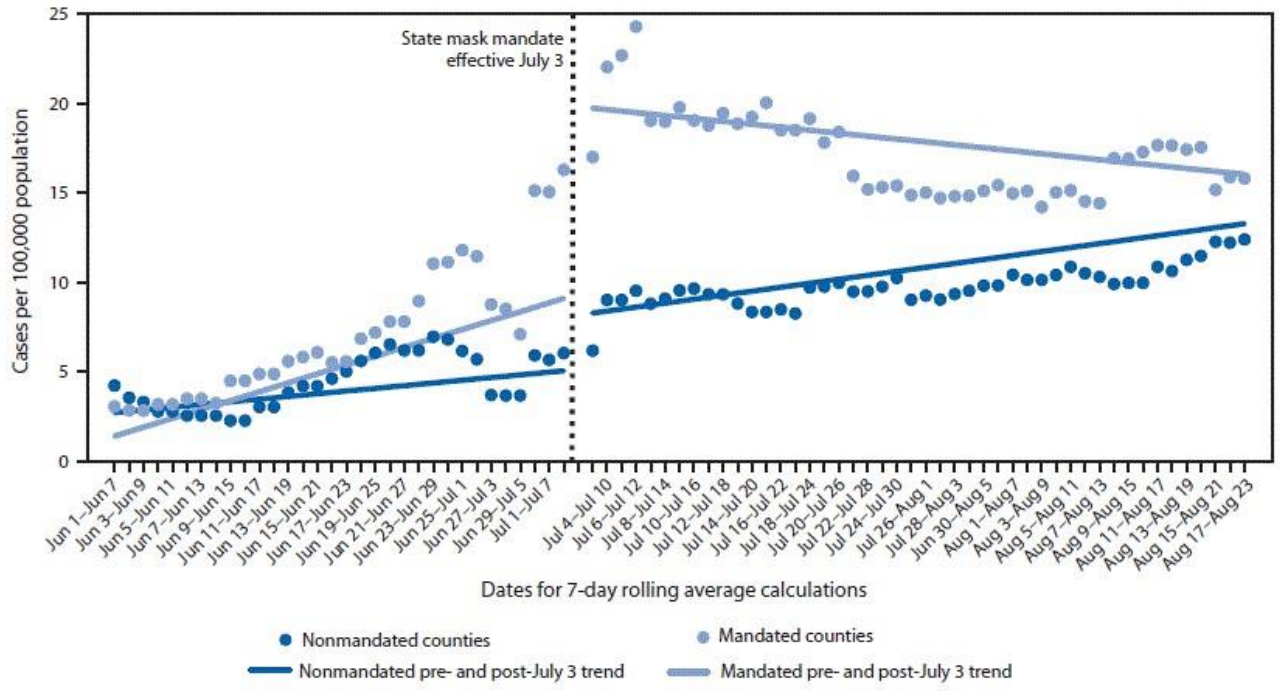

Figure 1: Trends in 7-day rolling average new daily COVID-19 cases per 100,000 populations among mask mandated and non-mask-mandated counties in Kansas (Van Dyke, 2020).

Before the mask mandate, all counties new COVID-19 daily cases were trending upwards. After the mandate, the counties that required masks show a downward trend in new cases by population where as non-mandated counties continued to trend upward. Another study, conducted by Vanderbilt University's Department of Health Policy, showed that counties without mask mandates in Tennessee had COVID-19 death tolls that were twice as high as those with mask mandates (Hubbard, 2021).

There is evidence to show that mask wearing helps slow the spread of COVID-19 and, therefore, the new public transportation mandates should help reduce the transmission of the virus and ease some public concern.

Health Checks and Temperature Screenings

Many businesses and public buildings have implemented temperature screenings and health check surveys for all visitors as a way to screen for any possible COVID-19 symptoms. It has also been a requirement for many employees to have their temperature taken each work day. Employee health checks and temperature screenings can be easily implemented for public transit agencies; however, more widespread screenings are less common. Many Asian cities have implemented temperature check kiosks and smart bus shelters equipped with sterilizers and thermal imaging cameras to help keep transportation workers and passengers safer (Chandran,
2020). This type of technology could help avoid disease transmission by identifying symptomatic passengers.

Health and Safety Concerns

Public transportation agencies have seen a decrease in ridership since the onset of the COVID-19 pandemic. In March and April of 2020, that decrease can be largely attributed to the fact that people were staying home as schools and businesses closed. The CDC had released a statement in June that discouraged the use of public transportation as many people were returning to work. The CDC advised people that as they leave their homes that they should drive alone in order to avoid COVID-19 (Callahan, 2020). As concern for COVID-19 grew, public transportation ridership dropped. Mobility trend data provided by Apple show greater increases in driving and walking trends compared to public transit since early 2020. These data were compiled by collecting Apple Maps direction requests and do not represent exact ridership numbers. Figure 2 shows the mobility trends provided by Apple for the U.S.

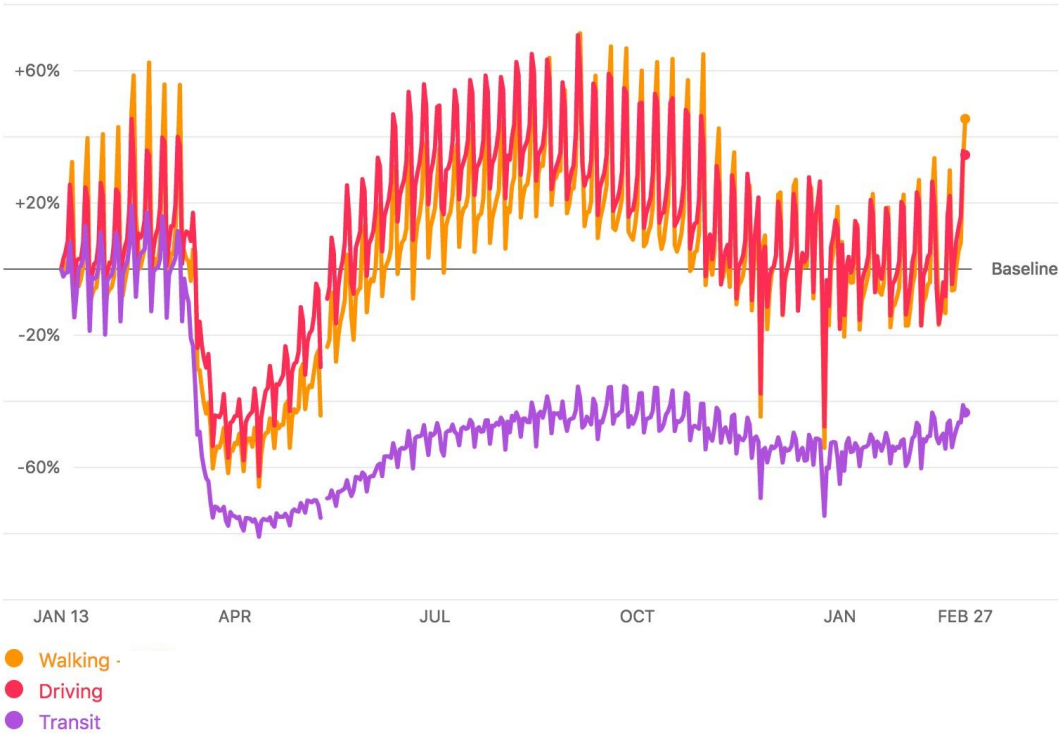

Figure 2: Apple Mobility Trends for the United States from January 13, 2020-February 28, 2021

According to the mobility trends from Apple, transit usage is down 43 percent nationally while walking and driving are up 45 percent and 35 percent respectively since January 13, 2020. Even though trend data are showing that more people are requesting directions for driving or walking, studies have shown that riding public transit is relatively safe during the COVID-19 pandemic. Many scientists believe that most intra-urban trips are too short to pose much risk for transmission of the virus (Wilson, 2020). One study conducted by Kyoto University in Japan found that from January through April of 2020, no super spreader events took place on public transportation (Wilson, 2020).

Summary

There have been various studies about the effectiveness of mask wearing, disinfecting of surfaces, and health checks in preventing the transmission of COVID-19 and other viruses. It is clear that many public transportation agencies have already implemented preventative measures since early 2020, and new technologies and new operating approaches are constantly emerging. Throughout the COVID-19 pandemic, ridership of public transportation has declined greatly. While several studies have examined this decline ridership, much has been studied or discussed in regard to the effect of the virus on future ridership. A better understanding of public concern regarding their own health and safety while riding on public transportation could help agencies prepare better for future events, prioritize resource allocation, and maintain and predict future ridership.

Chapter 3: Methodology

The COVID-19 pandemic raised a whole new set of questions for transportation users, and due to its unprecedented nature, there is very little known or researched on the effects of the pandemic on the country's transportation systems. To study the possible long term effects of the pandemic on transportation, a survey was used to investigate public concerns and opinions on public transportation usage after the onset of COVID-19 and during the associated social restrictions related to the virus.

There are a variety of techniques and modes that survey researchers can use in data collection including: in person, telephone, internet, or paper (Pew Research Center). The mode in which a survey is conducted, as well as the survey design, can influence the responses and should be considered carefully. The different methods vary in cost, efficiency, accessibility, and responsive rates. For this survey, an online survey was chosen due to lower cost, higher efficiency, and the ability to reach a wide population, especially during a pandemic.

Use of Online Surveys

The use of the internet as a mode for survey administration has many advantages. As mentioned previously, this mode was chosen due to lower cost and higher efficiency. This study was able to reach its goal of 1000 participants quickly, and the total subject payment was relatively inexpensive ($0.15 paid to each participant). In addition, web surveys have less social desirability bias compared to interviewer-administered modes, and respondents have the convenience of completing the survey on their own time at their own pace (Pew Research). One of the drawbacks of internet surveys is coverage bias. These surveys rely on people who have access to and use the internet. Typically, people with lower incomes, less education, living in rural areas, or older than the age of 65 are underrepresented among internet users. However, according to Pew Research in 2019, only 10 percent of U.S. adults say they do not use the

internet (Anderson, 2019). It is important to be cautious when generalizing results of a web survey due to this coverage bias.

Survey participants can be recruited using a variety of techniques. One common technique is to use an online crowdsourcing service, which was the approach chosen for this study. Although there are many crowdsourcing services, one of the most popular is Amazon's Mechanical Turk (MTurk), which was used for this survey. MTurk offers developers, businesses, or other individual researchers (requesters) an opportunity to submit small human intelligence tasks (HITs) for workers to complete. The workers receive a small fee for completing tasks from the requester. As these workers are pre-registered with the platform, the likelihood of the coverage bias mentioned earlier is greater. Another potential bias that arises is self-selection bias.

Due to this sampling technique, "workers" choose whether or not they complete any given task based on the description. Demographic and other questions can be used to categorize the sample. Since workers can complete tasks so rapidly, are unsupervised and anonymous, and are financially motivated, there could be problems with responses being incomplete or questions not read carefully (Hauser, 2015).

Participant attentiveness is a concern when conducting surveys on MTurk. The platform allows for responses to be rejected due to incompleteness or short response durations. If a participant could not have reasonably taken their survey in a certain time, then their responses can be removed due to a clear lack of attention to the questions. In a 2015 study, participants on MTurk were compared to collegiate populations. Both populations completed a task that included a measure of attentiveness. In all three studies, MTurk workers passed an instructional manipulation check (IMC) at a higher rate than other subject pools (Hauser, 2015). Other studies have proved similar results suggesting that MTurk workers are typically attentive.

Survey

The primary objective of the survey was to establish a baseline of public concerns related to public transportation since the start of the COVID-19 pandemic. The survey was designed with questions meant to answer these four main points:

- How concerned are people about the use of public transportation because of COVID-19?
- What safety procedures will effectively ease any public concern with public rail and bus transportation?
- How likely are people to resume use of public transportation in a post-pandemic environment, or will they seek alternate forms of transportation? How will demand for public transportation change?
- How will personal financial situations effect people's decisions about public transportation usage?

The final survey that was distributed can be found in Appendix A. Within the survey, respondents were asked four types of questions:

- Questions about participants' transportation experiences
- Questions about participants' general concern about riding public transportation and COVID-19-related safety procedures
- Questions about how the COVID-19 pandemic has affected individuals' financial situations.
- Demographic questions

The general questions about participants' transportation experiences were designed to answer the main objective of understanding how transportation demand will change. Participants were asked about their frequency of ridership on commuter rail, underground rail/subway, and buses on a seven-point scale ranging from never to multiple times a day. This question asked the respondents to characterize their

tripmakng before, during, and after the pandemic to learn if there was a change in ridership. It would be useful to know that a participant would never use public transportation after the pandemic if they never did before; therefore, it was important to ask respondents about their pre-pandemic usage. In addition to these three questions, respondents were asked for information about whether they own or have access to a personal vehicle, if they have a driver's license, and what is their primary means of transportation. These questions explored other factors that could influence the participants' decision making process.

The questions about general concern with riding public transportation and safety procedures were designed to answer the first two main concerns, the level of public concern and what safety procedures might ease that concern. The third group of survey questions asked participants to rank their level of concern when using each of the three modes of public transportation since the COVID-19 pandemic on a five point Likert scale with an additional "no opinion/not sure" option. Other questions asked participants to rank a list of COVID-related safety procedures as well as asking their willingness to pay an increased fee to the service provider for these enhanced procedures.

There were a set of questions designed to understand if a user's personal financial situation would affect their transportation decision making. The survey, therefore, contained questions about how the COVID-19 pandemic affected a person's financial situation. For
example, participants were asked if they were laid off or furloughed due to the pandemic.

The final type of questions were demographic questions. These questions were used in the analysis to see if the survey sample was representative of the U.S. population of transportation users and check for possible coverage bias. These questions were also of interest to see if different groups have different levels of concern. For example, it was hypothesized that age would be a factor that would account for different levels of concern since the older population is considered more "at-risk" for contracting and being severely affected by COVID-19.

Before the survey was published, it was reviewed by the experimenter and the study supervisor. In addition, the final survey was reviewed by a member of the senior staff at the American Public

Transportation Association (APTA), an industry group representing a broad variety of U.S. public transportation operators.

Data Analysis

The survey was published on MTurk on September 3, 2020 and completed by 1000 participants that same day. The data then had to be cleaned, reduced, and evaluated to prepare it for detailed analysis.

Data Cleaning

Data cleaning is the process of making sure data is consistent and usable. As mentioned earlier, participant attentiveness is a concern with web surveys. Data cleaning can help correct for that as well as find and remove transcription or coding errors.

For this survey, demographic questions were not required (instead of a 'prefer not to answer' option) and therefore only blank responses for the first batch of questions were removed. Blank responses in the demographics section remained. Therefore, 84 participants were removed for incomplete responses in the first section of the survey.

Based on the experimenter's performance during the survey testing, it was determined that the survey could not be thoughtfully completed in less than two and a half minutes. To account for participants who may have rushed to provide answers and not fully read the questions, responses that took less than two and a half minutes to complete were removed. This was a total of 396 participants. After removing participants for incompleteness and duration, 520 responses were left for analysis.

Analysis Methods

Once the data were cleaned, a variety of descriptive statistics were used to summarize the results. Initially, responses to each question were summarized in frequency tables to allow a preliminary examination of the results in organized, easily-digestible format. A full set of frequency tables can be found in Appendix B. Frequency tables are the most straightforward way to perform a first level analysis of the results. Some cross-tabulations of select data pairs were then performed to examine how responses varied by demographic measures.

Paired Sample T-Test

As mentioned, one of the main objectives of this study was to understand how participants' public transportation usage would change because of the COVID-19 pandemic. To see if the pandemic would decrease participants' ridership frequencies, three paired sample, lower-tailed t-tests were conducted on the ridership frequencies before and after the start of the pandemic for each mode of transportation. This test was performed using Excel Data Analysis functions.

There are four assumptions that need to be met for a t-test to be performed. First, the dependent variable must be continuous. For the questions tested, a seven-point Likert scale is used and coded to a numerical scale and therefore the first assumption is met. The second assumption is that the observations are independent of each other. This is met since the respondents were independent of each other. The next two assumptions are that the dependent variable is normally distributed and that it should not contain outliers. Normality was confirmed by the central limit theorem, since the sample size is very large, and there are no outliers observed in this data set.

In a paired sample t-test, each subject is measured twice, creating pairs of observations. There are two competing hypotheses in this analysis, the null (H_0) and the alternative (H_a) hypotheses. The null hypothesis assumes that the true mean difference ($\square_d$) between the paired samples is equal to zero while the alternative hypothesis assumes that the mean difference is equal to something other than zero. In this analysis, the assumption is that ridership on public transportation will decrease after the pandemic compared to ridership before the pandemic. Therefore, the alternative hypothesis is more specifically that the difference in response is less than zero or negative and a lower-tailed t-test is performed ("Paired Sample T-Test", n.d.). The difference was calculated by subtracting respondents' answers on one question from their answers on the other question and taking an average. The test statistic, t, is calculated according to the following formula:

$$t = \frac{\bar{x} - \mu_d}{s.e.}$$

Where

$$\bar{x} = sample\ mean\ of\ differences$$

$$\mu_d = true\ mean\ difference\ (assumed\ to\ be\ 0)$$

$$s.e. = estimated\ standard\ error\ of\ means$$

The probability of observing a difference as extreme as the t-statistic is calculated (pvalue). For 95 percent confidence, the null hypothesis is rejected if the p-value is less than 0.05.
This means that 95 percent of the time the difference is greater than zero.

Kruskal-Wallis Tests

For this study, a main objective was to determine if participants' personal financial situations had an effect on level of concern of public transportation usage since the COVID-19 pandemic. In addition, it was interesting to note if different demographic groups had differing levels of concerns as well. Kruskal Wallis Tests were performed on question four of the survey:
"How concerned are you to utilize the following modes of public transportation since the start of the COVID-19 pandemic?"

There are three assumptions of the Kruskal-Wallis tests. The first is that dependent variable is ordinal or continuous. Question four was a five-point Likert scale and therefore meets the continuous assumption. It is also assumed that the observations are independent of each other, which has been confirmed previously. Finally, the independent variable consists of independent, categorical groups ("Kruskal-Wallis Test", 2020). This condition is met since demographic questions such as age, gender, ethnicity, income, education, and location are all categorical groups. In addition, the questions regarding financial situations resulting from COVID-19 subgroups are categorical. For example, the question asking the participants how their financial situation has changed can be grouped into, "better off", "worse off", and "about the same".

The Kruskal-Wallis test is a non-parametric alternative to ANOVA when the assumption of normality is not met. This test determines if the medians of two or more groups are different and a test statistic is calculated (Glen, 2016). This test consists of a null hypothesis and an alternative hypothesis. The null hypothesis assumes that the subgroups are identical to each other. The alternative hypothesis assumes that at least one of the subgroups differs. The test statistic used in this analysis is the H-statistic. The H-statistic is calculated using the following equation.

$$H = [\frac{12}{n(n+1)} \sum_{j=1}^{c} \frac{{T_j}^2}{n_j}] - 3(n+1)$$

where

$$n = sum\ of\ sample\ sizes\ for\ all\ samples$$

$$c = number\ of\ samples$$

$$T_j = sum\ of\ ranks\ in\ the\ j^{th}\ sample$$

$$n_j = ssize\ of\ the\ j^{th}\ sample$$

Like the t-test, the probability of observing an H-statistic is calculated to find a p-value. If the p-value is less than 0.05 then there is a statistically different distribution of responses and the null hypothesis is rejected.

Chapter 4: Results

The survey generated a baseline set of results about public concern and habits regarding public transportation usage since the onset of the COVID-19 pandemic. This chapter will present those results and provide a summary description of the subject pool, a detailed discussion of each question, as well as statistical analyses of the data.

Results of each survey question were initially compiled into frequency tables to perform an initial analysis of the validity of the results. The full set of frequency tables can be found in Appendix B. Participants' demographic information as well as their public transportation habits and concerns were collected. Demographic data are important in identifying trends and drawing conclusions about the general population. A descriptive profile of the 520 participants is provided in Table 1.

Table 1. Demographic Breakdown of 520 Survey Participants

Demographic Characteristics	Number of Respondents	Percent of Respondents
Ethnicity		
White	295	57%
African American	56	11%
Asian	126	24%
Hispanic	28	5%
Other	14	3%
Gender		
Female	221	43%
Male	293	57%
Other	4	1%
Education		
Some High School	1	0%
High School Graduate	31	6%
Some College, no degree	77	15%
College Graduate	309	60%
Postgraduate	100	19%

Demographic Characteristics	Number of Respondents	Percent of Respondents
Income		
$0-$29,999	128	25%
$30,000-$79,999	264	51%
$80,000-$149,000	100	19%
$150,000-$249,000	18	3%
$250,000	8	2%
Age Group		
18-24 years	60	12%
25-34 years	223	43%
35-44 years	117	23%
45-54 years	73	14%
55-64 years	28	5%
65-74 years	18	3%
75-84 years	1	0%

Overall the survey respondents represented a diverse group in terms of gender, age, education, income and ethnicity. Percentages of each ethnicity and age are relatively representative of the United States population according to the most recent data (2019) from the U.S Census Bureau. Although there is a smaller percentage of persons 65 and older than what is representative of the US population, it is most likely due to the coverage bias of an internet based survey. This bias should be considered in the analysis of results, bearing in mind, in the 2017 survey, "Who Rides Public Transportation", performed by the American Public Transportation Association (APTA), only 7 percent of public transportation users are 65 or older (Hugh, 2017, p. 17).

In addition to the demographic information, other questions regarding respondents' characteristics and habits were asked to gain an understanding of their transportation related backgrounds.

First, respondents were asked if they currently had a driver's license, and then asked if they owned or had access to a personal vehicle. These questions will be taken into consideration during the analysis of public transportation comfort levels. Of the respondents of this survey, 89 percent have a driver's license, and 81 percent have access to a personal vehicle. This should be noted during the analysis as the majority of respondents are not limited to only public transportation when choosing a mode of transportation and evaluating their comfort levels. Respondents were also asked to describe the area in which they live, as people in urban and suburban areas are more likely to have access to public transportation compared to those in rural areas. The respondents from urban and suburban areas accounted for 41 and 40 percent, respectively. Respondents from rural areas only made up 19 percent of total surveyed.

Next, respondents were asked about their primary means of transportation. Forty-two percent answered for either bus or rail which was the focus of this survey. Forty-nine percent use a personal vehicle as their primary mode. The breakdown of these answers is shown in Table 2.

Table 2: Survey Respondents' Primary Means of Transportation

What is your primary means of transportation for work/school?	
Bus	30%
Personal Vehicle	49%
Rail	12%
Taxi/Rideshare	3%
Other	6%

Finally, those surveyed were asked to select the two top factors that are a priority when choosing their transportation options from a list that included: cost, health, personal safety, availability, commute time, and other. The two factors selected most often were personal safety and health. This shows that the general public prioritizes their health and safety and may not travel using public transportation if they do not feel it is safe to do so. However, as seen in the Table 3, in terms of percentages, each factor carried a similar level of priority.

Table 3: Survey Respondents' Top Priorities When Choosing Transportation Modes

What are your top two priorities when choosing transportation options?	
Cost	18%
Health	21%
Personal Safety	30%
Availability	17%
Commute time	13%
Other	1%

A major question that this survey sought to answer was how personal financial situations affect peoples' decisions about public transportation usage. Those considered essential workers might have different opinions than those who work from home or those who might have lost their employment due to the pandemic.

One question asked was how the COVID-19 pandemic impacted respondents' work/school routine. Only 7 percent of respondents to this survey were laid-off or furloughed due to COVID-19. A total of 60 percent of respondents were still working remotely at the time of the survey completion, while 10 percent had been working remotely but had already returned to work in person. Respondents were then asked how their financial situation had changed since the start of the COVID-19 pandemic. Forty-eight percent of the respondents reported being worse off financially, 35 percent were about the same, and only 17 percent were better off. Financial considerations could affect how people choose transportation options. Out of the total respondents, 59 percent answered "yes" when asked if their job is considered "essential" during the pandemic.

Another goal of this survey was to determine what safety procedures, if any, will effectively ease people's concern in regard to public transportation usage. The survey had respondents rank safety

procedures on level of importance in their decision on whether or not to use public transit. The given safety procedures were: cleanliness of the vehicles, disinfecting of the vehicle frequently between passengers, employee health checks daily, mandatory face coverings for all employees, mandatory face coverings for all passengers, hand sanitizer availability within the vehicle or in the station, and enforced compliance with social distancing guidelines. Each ranking was weighted so that a ranking in first place carried a weight of seven and a ranking of seventh carried a weight of one. Figure 3 shows the total weighted rank of each safety procedure.

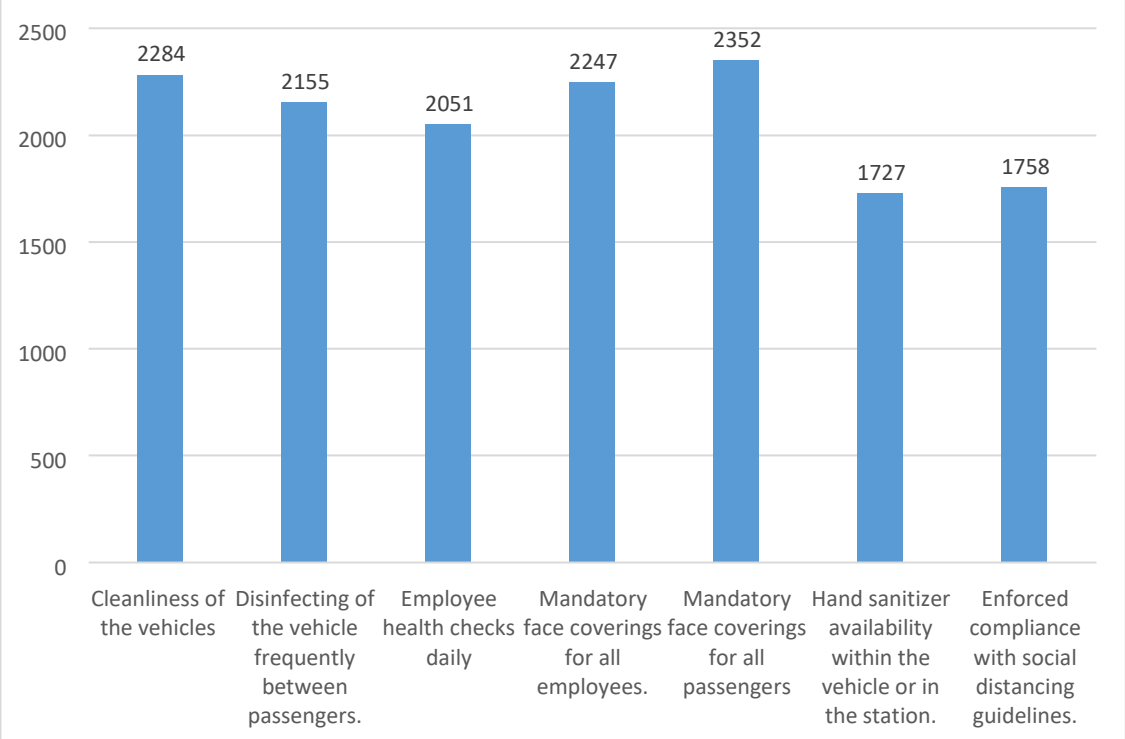

Figure 3: Weighted Rankings of Safety Procedures

Mandatory face coverings for all passengers ranked first overall, while mandatory face coverings for all employees ranked third. It can be concluded that people are more comfortable when others are wearing masks. Although the mandatory face coverings for all passengers measure ranked as the highest overall in importance, there does not seem to be a significant difference between the safety procedures. Due to the wording of survey questions, it is unclear if the public's opinions and concerns would differ

based on the density of the crowds on public transportation. It would be interesting to examine comfort levels based on the capacity of the public transportation modes.

Respondents were also asked how likely they are to pay an increased fee for public transportation to pay for the increased sanitation methods or renovations. Only 8 percent of respondents would not consider paying a higher fee, and an additional 25 percent were not likely to consider it. However, a majority of respondents were somewhat likely to pay a higher fee or would definitely pay more at 53 percent and 14 percent respectively.

The main objective of the survey was to determine the public's level of concern about public transportation since the start of the COVID-19 pandemic and predict public transportation usage in a post-COVID-19 world. The survey respondents were asked, "How concerned are you to utilize the following modes of transportation (commuter rail, subway/underground rail, and bus) since the start of the COVID-19 pandemic?" For this question, a five point Likert scale was used ranging from extremely concerned to not at all concerned with an additional no opinion/not sure option. The distribution of responses is shown in Figure 4.

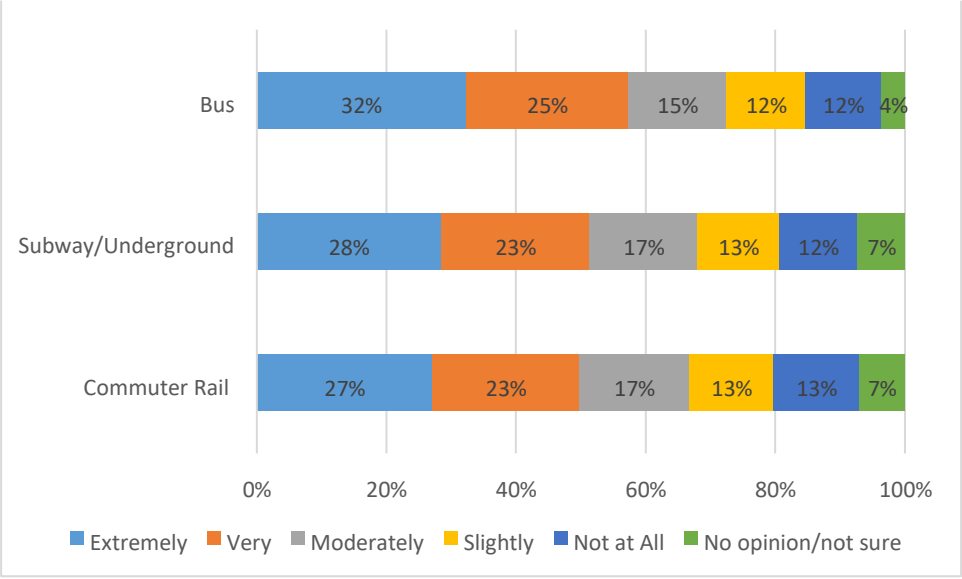

Figure 4: Level of concern to utilize three modes of public transportation: bus, subway/underground rail, and commuter rail

The different modes of transportation carry a near identical distribution of level of concern. Respondents who are extremely concerned of the bus was 32 percent while underground and commuter rail are only 28 and 27 percent respectively. For the other responses, there is not a percentage difference between the different modes greater than two, demonstrating that the public's level of concern carries across all different forms of public transportation. If the scale is collapsed, it can also be seen that half or more of respondents are extremely to very concerned at 57, 51 and 50 percent for bus, subway/underground rail, and commuter rail, respectively. Only 12 to 13 percent of the study participants have no concern when using public transportation. The majority of public transportation users now harbor some concern about using public transportation because of the COVID-19 pandemic.

To understand the changes in respondents' usage of each mode of public transportation, they were asked the same three questions about commuter rail, subway/underground rail, and buses. The questions were:

- Before the COVID-19 pandemic, how often did you use the following modes of transportation?
- During the COVID-19 pandemic, how often have you used the following modes of transportation (after May 1, 2020)?
- After the COVID-19 pandemic (when vaccine and treatments are available for immediate administration), how often do you plan to use the following modes of transportation?

In question 2, May 1, 2020, was used as a date because some workers who were initially remote returned to work on or near this date. The distributions in Figure 5, Figure 6, and Figure 7 shows the usage in the before, during, and after periods for Commuter Rail, Subway/Underground Rail, and Bus respectively.

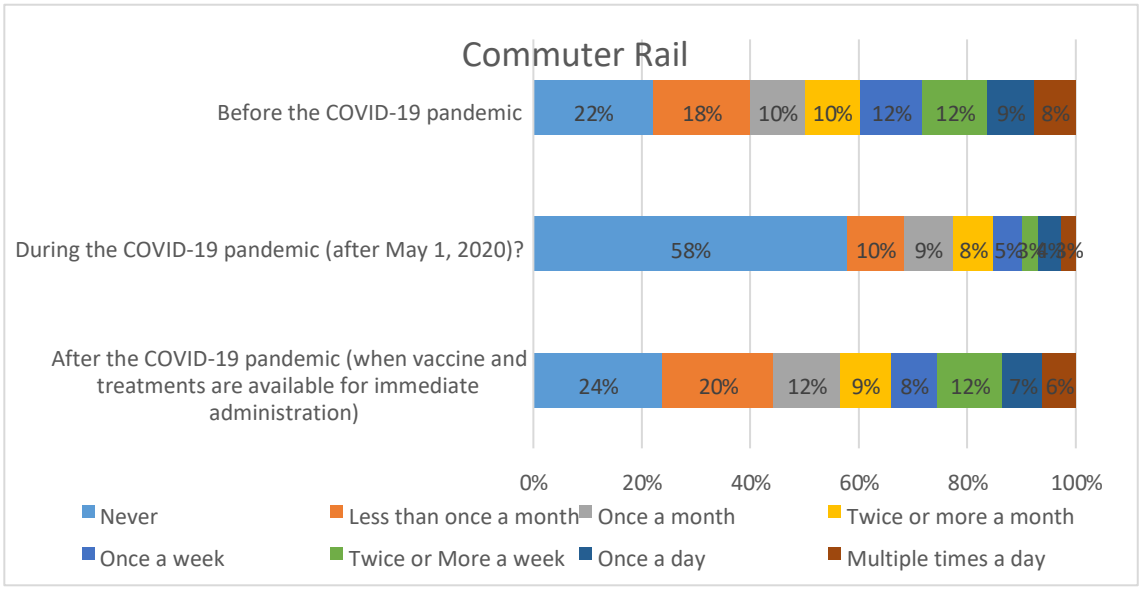

Figure 5: Survey respondents' commuter rail usage before and during the COVID-19 Pandemic as well as predicted usage after the Pandemic

During the COVID-19 pandemic, the percentage of people who never use commuter rail jumped from 22 to 58 percent. However, after the pandemic, the percentage returns to levels close to that of before the pandemic at 24 percent. The distributions before and after the pandemic appear similar.

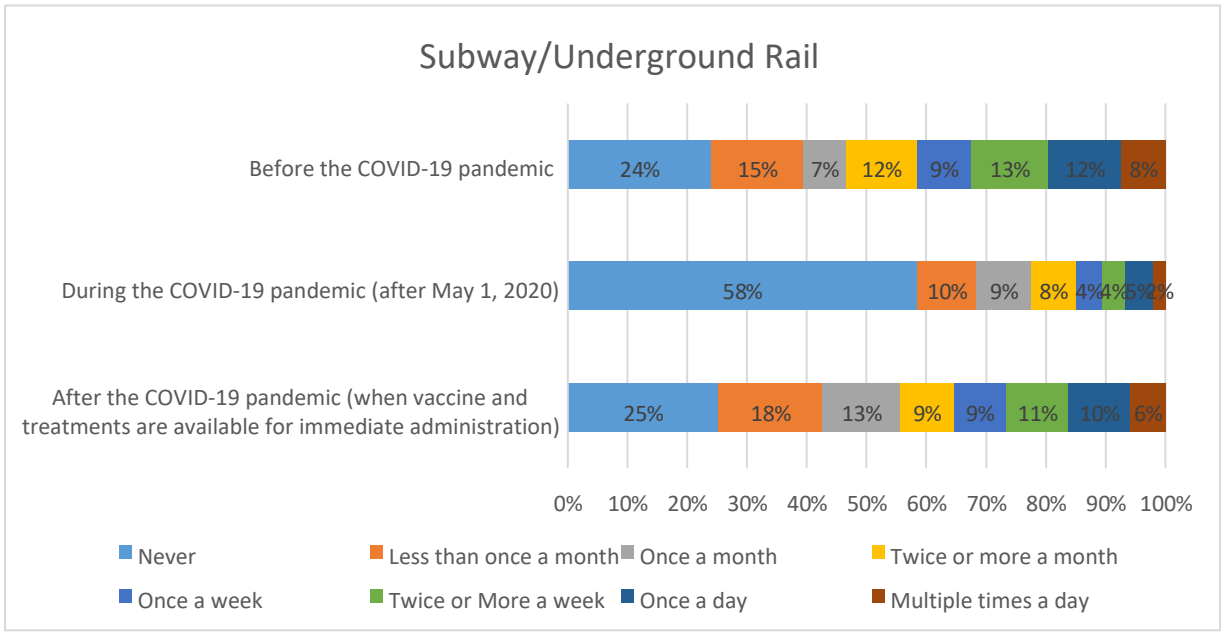

Figure 6: Survey respondents' subway/underground rail usage before and during the COVID-19 Pandemic as well as predicted usage after the Pandemic

Before the COVID-19 pandemic, 24 percent of the respondents never used the subway or underground rail. This number jumps to 58 percent during the pandemic, but returns to 25 percent after the pandemic. This distribution showed the same trends as that for commuter rail.

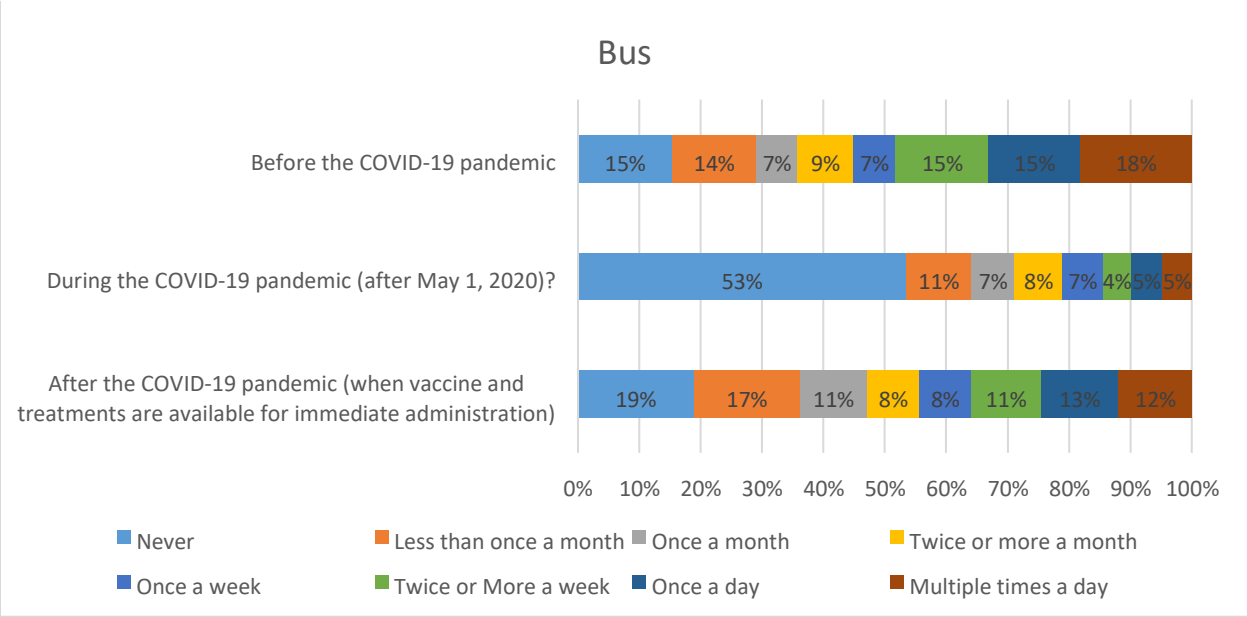

Figure 7: Survey respondents' bus usage before and during the COVID-19 Pandemic as well as predicted usage after the Pandemic

The same trends seen in commuter and underground rail can be seen again in the distributions for ridership on buses. Before the COVID-19 pandemic, 15 percent of the respondents said they never rode the bus. This percentage jumped to 53 percent during the pandemic; however, it is only 19 percent after the pandemic. For those respondents who rode the bus multiple times a day, there was a change from 18 percent before the pandemic to 12 percent post-pandemic. All three distributions show that most riders plan to return to similar public transportation choices post-COVID-19. However, during the pandemic there is, and it is expected that there will continue to be a drastic change in ridership.

Cross tabulations were created to show level of concern across different demographic groups for each mode of transportation studied. The full cross-tabulation tables can be found in Appendix C. Through visual inspection of the cross-tabulations, there does not seem to be any clear differences in responses among different subgroups.

Statistical Analysis

One of the primary objectives of this survey was to determine how likely people are to resume use of public transportation or if they will seek alternate methods, thus changing the demand for public transportation. Respondents were asked “Before the COVID-19 pandemic, how often did you use the following modes of transportation?”, and “After the COVID-19 pandemic (when vaccine and treatments are available for immediate administration), how often do you plan to use the following modes of transportation?” for commuter rail, subway/underground rail, and bus. A paired sample, lower-tailed t-test was performed to compare public transportation use from before and after the COVID-19 pandemic. The frequency of usage was coded on a scale of zero to seven, with zero being never used and seven being multiple times a day. The null hypothesis assumed that the difference in usage before and after the COVID-19 pandemic was equal to zero. The alternative hypothesis assumed that the difference was greater than zero.

Commuter Rail

The paired sample t-test compared the usage before the COVID-19 pandemic (2.8) with the mean of commuter rail usage after the COVID-19 pandemic (2.5) and resulted in a t-value of 3.55 and a p-value of 0.0002. With this p-value, the null hypothesis was rejected. There is a significant difference in predicted overall commuter rail ridership before and after the COVID-19 pandemic.

Subway/Underground Rail

The paired sample t-test compared the usage before the COVID-19 pandemic (2.9) with the mean of underground rail usage after the COVID-19 pandemic (2.6) and resulted in a t-value of 4.18 and a p-value that is less than 0.05 and, therefore, the null hypothesis was rejected. There is a significant difference in predicted overall underground rail ridership before and after the COVID-19 pandemic.

Bus

The paired sample t-test compared the usage before the COVID-19 pandemic (3.7) with the mean of bus usage after the COVID-19 pandemic (3.1) and resulted in a t-value of 6.76 and a p-value that is less than 0.05 and, therefore, the null hypothesis was rejected. There is a significant difference in predicted overall bus ridership before and after the COVID-19 pandemic.

Although initial analysis of the earlier distributions did not show an obvious difference in ridership, the t-tests indicate that overall people will decrease their ridership of all three forms of public transportation after the COVID-19 pandemic. This difference may be due to the fact that fewer people will need travel as remote working/learning continues, or people may be more concerned about the relative safety of using transit and move towards different forms of transportation. It is difficult to determine whether these self-predictions for future usage of public transportation will change over time as people are constantly learning new things about the virus. At the time of this survey, people had planned to use public transportation less, according to these results.

Level of Concern

In examining whether different groups had different levels of concern in regard to transportation usage, the Kruskal-Wallis test was performed for Survey Question 4 on each mode of transportation. To remove outliers, the "not sure/no opinion" responses were removed for this test. The Kruskal-Wallis test was performed to determine if there is a statistical difference between the demographic groups. This test was performed for Question 4 of the survey for commuter rail, underground rail, and bus where respondents were asked, "How concerned are you to utilize the following modes of public transportation since the start of the COVID-19 pandemic?", for age, gender, ethnicity, location, education, and household income. Returned pvalues that indicate the probability that the subgroups responded differently are shown in Table 4. P-values less than 0.05 were considered statistically significant and are highlighted in the table.

Table 4: Kruskal-Wallis p-values by demographic groups

	Age	Gender	Ethnicity	Location	Education	HHIncome
Commuter Rail	0.8973	0.06487	0.009438	0.04688	0.1934	0.6445
Underground Rail	0.352	0.006151	0.005718	0.2196	0.0908	0.1562
Bus	0.7646	0.4	0.0663	0.06407	0.8811	0.4236

There were no strong predictors of level of concern for bus ridership. Ethnicity is the only subgroup with p–value that is statistically significant for both commuter rail and underground rail. Location (suburban, urban, rural) appears to be a predictor for level of concern of commuter rail, while

gender is a predictor for level of concern regarding underground rail or subway. There does not seem to be a significant level of demographic factors to predict the public's level of concern to use public transportation.

Level of concern of each mode of transportation was also tested for the questions: "How has the COVID-19 pandemic impacted your work/school routine?", and "How has your financial situation changed since the COVID-19 pandemic?". For the question regarding impacted routine, respondents were given the multiple choice options(subgroups) of:

- I work/attend classes from home, and plan to continue remotely.
- I work/attend classes from home, but plan to return to the office/school.
- I worked/took classes from home, and have already returned to in-person operation.
- COVID-19 did not impact my work/school situation.
- I do not work, and I am not a student.
- I was laid-off or furloughed due to COVID-19.

The question regarding financial changes gave options(subgroups) of "worse off", "better off", or "about the same". Returned p-values are shown in Table 5.

Table 5: Kruskal-Wallis p-values by financial changes

	Impacted Routine	Financial Change
Commuter Rail	0.004785	0.1121
Underground Rail	0.911	0.8471
Bus	0.7012	0.1655

The only categorical group that demonstrated as a significant predictor for concern in using commuter rail was impacted work/school routine, which had a p-value of less than 0.05. Besides this factor, there does not seem to be any significant financial predictors for level of concern of public transportation.

Chapter 5: Conclusions

Transportation agencies and planners will have to make decisions about policy and funding for public transportation as the COVID-19 pandemic continues and when it is over. This pandemic has taken a toll on the public transportation industry and transformed the nature of public health and safety concerns related to these forms of travel. The primary purpose of this thesis was to understand public opinion and concerns regarding public transportation and COVID-19, and how this might change future ridership. This thesis also sought to determine if certain safety procedures and protocols will ease these concerns. Finally, information about how socio-economic factors might affect people's transportation choices during the COVID-19 pandemic was investigated.

A survey of 520 United States residents was conducted using Amazon's Mechanical Turk (MTurk) crowdsourcing marketplace to investigate opinions regarding these questions.

The findings of this study indicate that there is concern over the use of public transportation since the start of the COVID-19 pandemic. For each mode of transportation (bus, subway/underground rail, and commuter rail), about half of all survey respondents were very or extremely concerned about using public transportation. When asked about the frequency with which they utilize each mode of transportation before, during, and after the COVID-19 pandemic, the distributions from before and after the pandemic appeared similar for commuter rail, subway/underground rail, and bus transportation, but the results of multiple paired sample t-test revealed that for each mode of transportation there was a significant difference in predicted overall ridership before and after the pandemic. Overall ridership should increase post-COVID-19, but individually, people are not predicting that they will return to the same levels of public transportation usage as before the pandemic. It is very clear that people will decrease their ridership on public transportation after the pandemic is over.

Subjects were asked to rank seven different safety protocols that have been implemented or have been proposed to be implemented. These results were weighted so that a ranking in first place carried a

weight of seven and a ranking of seventh carried a weight of one. The resulting weighted rankings for each were close, but mandatory face coverings for both employees and passengers would ease public concern over the relative safety of using public transportation. The cleanliness of the vehicle was another important safety element for many of the survey respondents.

This thesis explored whether there is a difference relative to the concerns described above between different demographic groups. According to the Kruskal-Wallis tests, there are not strong predictors of level of concern for bus ridership. For commuter rail, ethnicity and location were predictors, and gender and ethnicity were predictors for underground rail. Overall, it does not seem that demographic subgroups are significant predictors of level of concern with public transportation usage. These tests also showed that there were not any significant economic predictors for level of concern.

It is clear that public transportation agencies have seen decreased ridership and revenue since the start of the COVID-19 pandemic. This study found that the level of public concern regarding the use of public transportation is high, and many people are not expecting that they will return to their pre-COVID19 ridership patterns. Transportation planners and agencies will need to determine how to adjust to these long term effects. Although this was only a preliminary investigation of public opinion regarding public transportation usage and concern due to the COVID-19 pandemic, these baseline data should allow agencies and planners to develop strategies and protocols to mitigate these concerns.

It is recommended that further research be done to develop a broader view of public opinion regarding relative safety effectiveness of safety countermeasures during a pandemic event. Other types of data collection can be used as to avoid the coverage bias that may be present due to a public crowdsourcing website. Other types of surveys, focus groups, or phone interviews of specific public transportation users could help verify the results of this survey. For this survey, almost half of the users listed a personal vehicle as their primary means of transportation and over 80 percent of respondents had

access to a personal vehicle. As this study sample was not all primarily public transportation users, it is recommended to complete future studies through specific transportation service providers.

Appendix A

Public Transportation Demand in a Post-Covid-19 World

You are invited to participate in a research study which involves completing a survey about public transit usage post-Covid-19. You must be 18 or older to participate.

Public Transportation Demand in a Post-Covid-19 World

Start of Block: Survey Questions

Q The following eight questions are related to the use of rail transportation systems (including underground and commuter rail) as well as bus transit.

Q1 Before the COVID-19 pandemic, how often did you use the following modes of transportation?

	Multiple times a day (1)	Once a day (2)	Twice or more a week (3)	Once a week (4)	Twice or more a month (5)	Once a month (6)	Less than once a month (7)	Never (8)
Commuter Rail (1)	○	○	○	○	○	○	○	○
Subway/Underground Rail (2)	○	○	○	○	○	○	○	○
Bus (3)	○	○	○	○	○	○	○	○

Q2 During the COVID-19 pandemic, how often have you used the following modes of transportation (after May 1, 2020)?

	Multiple times a day (1)	Once a day (2)	Twice or more a week (3)	Once a week (4)	Twice or more a month (5)	Once a month (6)	Less than once a month (7)	Never (8)
Commuter Rail (1)	○	○	○	○	○	○	○	○
Subway/Underground Rail (2)	○	○	○	○	○	○	○	○
Bus (3)	○	○	○	○	○	○	○	○

Q3 After the COVID-19 pandemic (when vaccine and treatments are available for immediate administration), how often do you plan to use the following modes of transportation?

	Multiple times a day (1)	Once a day (2)	Twice or more a week (3)	Once a week (4)	Twice or more a month (5)	Once a month (6)	Less than once a month (7)	Never (8)
Commuter Rail (1)	○	○	○	○	○	○	○	○
Subway/Underground Rail (2)	○	○	○	○	○	○	○	○
Bus (3)	○	○	○	○	○	○	○	○

Q4 How concerned are you to utilize the following modes of public transportation since the start of the COVID-19 pandemic?

	Extremely Concerned (1)	Very Concerned (2)	Moderately Concerned (3)	Slightly Concerned (4)	Not at all concerned (5)	Not sure/no opinion (6)
Commuter Rail (1)	○	○	○	○	○	○
Subway/Underground Rail (2)	○	○	○	○	○	○
Bus (3)	○	○	○	○	○	○

Q5 Rank the following safety procedures based on the level of importance in your decision whether or not to use public transit (1 is ranked as most important).

_____ Cleanliness of the vehicles and station. (1)
_____ Disinfecting of the vehicle frequently between passengers. (2)
_____ Employee health checks daily. (3)
_____ Mandatory face coverings for all employees. (4)
_____ Mandatory face coverings for all passengers. (5)
_____ Hand sanitizer availability within the vehicle or in the station. (6)
_____ Enforced compliance with social distancing guidelines. (7)

Q6 How has the COVID-19 pandemic impacted your work/school routine?

- ○ I work/attend classes from home, and plan to continue remotely. (1)
- ○ I work/attend classes from home, but plan to return to the office/school. (2)
- ○ I worked/took classes from home, and have already returned to in-person operation. (3)
- ○ COVID-19 did not impact my work/school situation. (4)
- ○ I do not work, and I am not a student. (5)
- ○ I was laid-off or furloughed due to COVID-19. (6)

Q7 How has your financial situation changed since the COVID-19 pandemic? Are you

- ○ Worse off? (1)
- ○ Better off? (2)
- ○ About the same? (3)

Q8 How likely are you to pay an increased fee for public transportation in order to pay for increased sanitation methods or renovations?

- ○ Would definitely pay more. (1)
- ○ Somewhat likely. (2)
- ○ Not likely. (3)
- ○ Would not consider. (4)

End of Block: Survey Questions

Start of Block: Demographic Questions

Q Please continue for a series of demographic questions.

Q9 What is your age?

- 18-24 years (1)
- 25-34 years (2)
- 35-44 years (3)
- 45-54 years (4)
- 55-64 years (5)
- 65-74 years (6)
- 75-84 years (7)
- 85+ years (8)

Q10 What gender do you identify as?

- Male (1)
- Female (2)
- Other (3)

Q11 What is your ethnicity?

- Hispanic (1)
- African American (2)
- White (3)
- Pacific Islander (4)
- Asian (5)
- Other (6)

Q12 Do you currently have a driver's license?

- Yes (1)
- No (2)

Q13 Do you currently own a personal vehicle or have one available for your use (i.e. company vehicle)?

- Yes (1)
- No (2)

Q14 What is your primary means of transportation for work/school?

- Bus (1)
- Rail (2)
- Taxi/Ride Share (3)
- Personal Vehicle (4)
- Other (5)

Q15 How would you describe the area in which you live?

- Suburban (1)
- Rural (2)
- Urban (3)

Q16 What is the highest level of education you have completed?

- Some high school (1)
- High school graduate (2)
- Some college, no degree (3)
- College graduate (4)
- Postgraduate (5)

Q17 What is your average household income?

- ○ $0 - $29,999 (1)
- ○ $30,000 - $79,999 (2)
- ○ $80,000 - $149,999 (3)
- ○ $150,000 - $249,999 (4)
- ○ $250,000 or more (5)

Q18 What are your top two priorities when choosing transportation options?

- ☐ Cost (1)
- ☐ Health (2)
- ☐ Personal Safety (3)
- ☐ Availability (4)
- ☐ Commute Time (5)
- ☐ None of the above/Other (6)

Q19 Do you perform a job that has been considered "essential" during the pandemic?

- ○ Yes (1)
- ○ No (2)

End of Block: Demographic Questions

Start of Block: Survey Code

Q22

Here is your MTurk Completion Code ${e://Field/Random%20ID}

Copy this code and paste into MTurk. When you have copied this code, click the next button to submit the survey.

End of Block: Survey Code

Appendix B: Frequency Tables of Survey Results of 520 Participants

Commuter Rail	Before the COVID-19 pandemic, how often did you use the following modes of transportation? - Commuter Rail	During the COVID-19 pandemic, how often have you used the following modes of transportation (after May 1, 2020)? - Commuter Rail	After the COVID-19 pandemic (when vaccine and treatments are available for immediate administration), how often do you plan to use the following modes of transportation? - Commuter Rail
Never	115	301	124
Less than once a month	93	54	106
Multiple times a day	40	14	32
Once a day	45	22	38
Once a month	52	47	64
Once a week	60	28	44
Twice or more a month	53	39	49
Twice or More a week	62	15	63
Total	520	520	520

Subway/Underground	Before the COVID-19 pandemic, how often did you use the following modes of transportation? - Subway/Underground Rail	During the COVID-19 pandemic, how often have you used the following modes of transportation (after May 1, 2020)? - Subway/Underground Rail	After the COVID-19 pandemic (when vaccine and treatments are available for immediate administration), how often do you plan to use the following modes of transportation? - Subway/Underground Rail
Never	125	304	131
Less than once a month	80	52	91
Multiple times a day	39	11	31
Once a day	63	24	53
Once a month	37	47	67
Once a week	47	23	45
Twice or more a month	62	39	47
Twice or More a week	67	20	55
	520	520	520

Bus	Before the COVID-19 pandemic, how often did you use the following modes of transportation? - Bus	During the COVID-19 pandemic, how often have you used the following modes of transportation (after May 1, 2020)? - Bus	After the COVID-19 pandemic (when vaccine and treatments are available for immediate administration), how often do you plan to use the following modes of transportation? - Bus
Never	80	278	98
Less than once a month	71	55	90
Multiple times a day	95	25	62
Once a day	77	27	66
Once a month	35	37	57
Once a week	36	35	44
Twice or more a month	47	40	44
Twice or More a week	79	23	59
	520	520	520

Question 4: How concerned are you to utilize the following modes of public transportation since the start of the COVID-19 pandemic?

	Commuter Rail	Subway/Underground	Bus
Extremely	141	148	168
Very	118	119	130
Moderately	88	87	79
Slightly	68	65	63
Not at All	68	63	61
No opinion/not sure	37	38	19
	520	520	520

Question 5: Rank the following safety procedures based on the level of importance in your decision whether or not to use public transit (1 is ranked as most important).

	Cleanliness of the vehicles	Disinfecting of the vehicle frequently between passengers.	Employee health checks daily	Mandatory face coverings for all employees.	Mandatory face coverings for all passengers	Hand sanitizer availability within the vehicle or in the station.	Enforced compliance with social distancing guidelines.
1	108	82	72	38	115	45	60
2	87	74	58	115	86	53	47
3	60	76	90	92	72	64	66
4	71	80	74	108	68	57	62
5	78	82	74	81	81	58	66
6	72	65	79	56	58	129	61
7	44	61	73	30	40	114	158
	520	520	520	520	520	520	520

Question 6: How has the COVID-19 pandemic impacted your work/school routine?

COVID-19 did not impact my work/school situation.	80
I do not work, and I am not a student.	42
I was laid-off or furloughed due to COVID-19.	36
I work/attend classes from home, and plan to continue remotely.	189
I work/attend classes from home, but plan to return to the office/school.	128
I worked/took classes from home, and have already returned to in-person operation.	45
	520

Question 7: How has your financial situation changed since the COVID-19 pandemic? Are you

About the same?	182
Better off?	87
Worse off?	251
	520

Question 8: How likely are you to pay an increased fee for public transportation in order to pay for increased

Would not consider	39
Not Likely	130
Somewhat likely	278
Would definitely pay more.	73
	520

Question 9: What is your age?

18-24 years	60
25-34 years	223
35-44 years	117
45-54 years	73
55-64 years	28
65-74 years	18
75-84 years	1
	520

Question 10: What gender do you identify as?

Female	221
Male	293
Blank	2
Other	4
	520

Question 11: What is your ethnicity?

White	295
African American	56
Asian	126
Hispanic	28
Other	14
Blank	1
	520

Question 12: Do you currently have a driver's license?

Yes	458
No	56
Blank	6
	520

Question 13: Do you currently own a personal vehicle or have one available for your use (i.e. company vehicle)?

Yes	418
No	100
Blank	2
	520

Question 14: What is your primary means of transportation for work/school?

Bus	156
Personal Vehicle	257
Rail	62
Taxi/Rideshare	15
Other	30
Blanks	0
	520

Question 15: How would you describe the area in which you live?

Suburban	213
Urban	205
Rural	96
Blanks	6
	520

Question 16: What is the highest level of education you have completed?

Some High School	1
High School Graduate	31
Some College, no degree	77
College Graduate	309
Postgraduate	100
Blanks	2
	520

Question 17: What is your average household income?

$0-$29,999	128
$30,000 - $79,999	264
$80,000 - $149,999	100
$150,000 - $249,999	18
$250,000 or more	8
Blanks	2
	520

Question 18: What are your top two priorities when choosing transportation options?

Cost	191
Health	230
Personal Safety	326
Availability	178
Commute time	138
Other	8
	1071

Question 19: Do you perform a job that has been considered "essential" during the pandemic?

Yes	305
No	215
Blanks	0
	520

Appendix C: Cross Tabulations of Survey Results

How concerned are you to utilize the following modes of public transportation since the start of the COVID-19 pandemic? - **Commuter Rail**

age	**Extremely Concerned**	**Very Concerned**	**Moderately Concerned**	**Slightly Concerned**	**Not at all concerned**	**Not sure/no opinion**
18-24 years	23.33%	30%	20%	8.33%	13.33%	5%
25-34 years	27.80%	24.66%	15.26%	10.31%	13.90%	8.07%
35-44 years	23.93%	18.80%	20.51%	18.80%	10.26%	7.69%
45-54 years	26.03%	21.92%	16.44%	13.70%	15.69%	6.85%
55-64 years	28.57%	21.43%	17.86%	14.29%	10.71%	7.14%
65-74 years	55.56%	0%	5.56%	22.22%	16.67%	0%
75-84 years	0%	100%	0%	0%	0%	0%
gender	**Extremely Concerned**	**Very Concerned**	**Moderately Concerned**	**Slightly Concerned**	**Not at all concerned**	**Not sure/no opinion**
Female	27.15%	23.53%	18.10%	12.22%	12.22%	6.79%
Male	27.30%	21.50%	16.04%	13.99%	13.99%	7.17%
Other	0%	50%	25%	0%	0%	25%
No Answer	50%	50%	0%	0%	0%	0%
Ethnicity	**Extremely Concerned**	**Very Concerned**	**Moderately Concerned**	**Slightly Concerned**	**Not at all concerned**	**Not sure/no opinion**
African American	25%	17.86%	16.07%	16.07%	14.28%	10.71%
Asian	16.67%	23.81%	22.22%	15.08%	14.29%	7.94%
Hispanic	28.57%	17.86%	10.71%	21.43%	10.71%	10.71%
White	31.19%	23.39%	15.25%	11.19%	9.49%	6.10%
Other	42.86%	21.43%	21.43%	7.14%	7.14%	0%
No Answer	0%	100%	0%	0%	0%	0%
Primary means of transportation	**Extremely Concerned**	**Very Concerned**	**Moderately Concerned**	**Slightly Concerned**	**Not at all concerned**	**Not sure/no opinion**
Bus	25.64%	23.08%	16.67%	14.10%	13.46%	7.05%
Personal Vehicle	26.85%	22.57%	17.51%	15.17%	10.89%	7.01%
Rail	32.26%	17.74%	12.90%	9.68%	22.58%	4.84%

Taxi/Rideshare	20%	40%	6.67%	6.67%	20%	6.67%
Other	30%	23.33%	26.67%	0%	6.67%	13.33%
Location	**Extremely Concerned**	**Very Concerned**	**Moderately Concerned**	**Slightly Concerned**	**Not at all concerned**	**Not sure/no opinion**
Suburban	28.17%	24.41%	13.62%	11.74%	14.08%	7.98%
Urban	27.32%	22.44%	20.49%	14.15%	10.73%	4.89%
Rural	22.92%	20.83	14.58%	14.58%	16.67%	10.42%
No Answer	50%	0%	50%	0%	0%	0%
Education	**Extremely Concerned**	**Very Concerned**	**Moderately Concerned**	**Slightly Concerned**	**Not at all concerned**	**Not sure/no opinion**
Some High School	0	0	0	0	0	100%
High School Graduate	35.48%	35.48%	12.90%	3.23%	12.9%	0
Some college, no degree	31.17%	23.37%	15.58%	10.39%	10.39%	9.09%
College graduate	25.57%	20.71%	17.80%	15.21%	13.59%	7.12%
Postgraduate	27%	24%	16%	12%	14%	7%
No answer	0	50%	50%	0	0	0

How concerned are you to utilize the following modes of public transportation since the start of the COVID-19 pandemic? - **Subway/Underground Rail**

age	**Extremely Concerned**	**Very Concerned**	**Moderately Concerned**	**Slightly Concerned**	**Not at all concerned**	**Not sure/no opinion**
18-24 years	13.33%	23.33%	23.33%	6.67%	10%	6.67%
25-34 years	26.46%	22.87%	20.63%	11.66%	11.21%	7.17%
35-44 years	21.37%	25.64%	21.37%	11.96%	9.40%	10.26%
45-54 years	8.22%	20.55%	13.70%	16.43%	9.56%	9.56%
55-64 years	35.71%	25%	10.71%	7.14%	7.14%	10.71%
65-74 years	27.78%	22.22%	22.22%	5.55%	5.55%	5.55%
75-84 years	0	100%	0	0	0	0

gender	Extremely Concerned	Very Concerned	Moderately Concerned	Slightly Concerned	Not at all concerned	Not sure/no opinion
Female	28.96%	22.17%	17.65%	13.57%	11.76%	5.88%
Male	27.64%	23.55%	15.70%	11.94%	12.63%	8.53%
Other	25%	25%	50%	0	0	0
No Answer	100%	0	0	0	0	0
Ethnicity	**Extremely Concerned**	**Very Concerned**	**Moderately Concerned**	**Slightly Concerned**	**Not at all concerned**	**Not sure/no opinion**
African American	32.14%	25%	17.86%	8.93%	12.5%	3.57%
Asian	23.81%	23.01%	15.08%	14.28%	16.67%	7.14%
Hispanic	42.86%	21.43%	25%	7.14%	0	3.57%
White	27.12%	22.37%	16.95%	13.22%	11.86%	8.47%
Other	57.14%	28.57%	0	7.14%	0	7.14%
No Answer	0	0	100%	0	0	0
Primary means of transportation	**Extremely Concerned**	**Very Concerned**	**Moderately Concerned**	**Slightly Concerned**	**Not at all concerned**	**Not sure/no opinion**
Bus	25.64%	21.79%	17.95%	15.38%	13.46%	5.77%
Personal Vehicle	28.79%	24.12%	17.12%	13.23%	8.56%	8.17%
Rail	27.42%	17.74%	11.29%	6.45%	27.42%	9.68%
Taxi/Rideshare	26.67%	26.67%	26.67%	6.67%	13.33%	0
Other	43.33%	26.67%	13.33%	6.67%	3.33%	6.67%
Location	**Extremely Concerned**	**Very Concerned**	**Moderately Concerned**	**Slightly Concerned**	**Not at all concerned**	**Not sure/no opinion**
Rural	22.92%	19.79%	18.75%	21.87%	9.37%	7.29%
Suburban	28.64%	27.23%	13.61%	9.39%	12.21%	8.92%
Urban	30.73%	20%	18.54%	11.71%	13.17%	5.85%
No answer	33.33%	16.67%	33.33%	0	16.67%	0
Education	**Extremely Concerned**	**Very Concerned**	**Moderately Concerned**	**Slightly Concerned**	**Not at all concerned**	**Not sure/no opinion**
Some High School	0	100%	0	0	0	0
High School Graduate	41.93%	19.35%	19.35%	3.22%	12.90%	3.22%

Some college, no degree	35.06%	23.38%	10.39%	6.49%	10.39%	14.28%
College graduate	25.24%	21.68%	18.12%	14.56%	12.94%	7.44%
Postgraduate	30%	25%	17%	14%	11%	3%
No answer	0	100%	0	0	0	0

How concerned are you to utilize the following modes of public transportation since the start of the COVID-19 pandemic? - **Bus**

age	**Extremely Concerned**	**Very Concerned**	**Moderately Concerned**	**Slightly Concerned**	**Not at all concerned**	**Not sure/no opinion**
18-24 years	30%	26.67%	13.33%	13.33%	11.67%	5%
25-34 years	38.56%	23.32%	16.59%	10.31%	8.07%	3.14%
35-44 years	30.77%	26.49%	12.82%	9.40%	15.38%	5.13%
45-54 years	24.66%	24.66%	15.07%	16.44%	16.44%	2.74%
55-64 years	21.43%	32.14%	10.71%	10.71%	21.43%	3.57%
65-74 years	22.22%	16.67%	27.78%	33.33%	0	0
75-84 years	0	100%	0	0	0	0
gender	**Extremely Concerned**	**Very Concerned**	**Moderately Concerned**	**Slightly Concerned**	**Not at all concerned**	**Not sure/no opinion**
Female	31.22%	24.89%	14.03%	13.12%	13.57%	3.17%
Male	33.79%	24.23%	15.70%	11.60%	10.58%	4.09%
Other	0	50%	50%	0	0	0
No Answer	0	100%	0	0	0	0
Ethnicity	**Extremely Concerned**	**Very Concerned**	**Moderately Concerned**	**Slightly Concerned**	**Not at all concerned**	**Not sure/no opinion**
African American	44.64%	21.43%	19.64%	7.14%	5.36%	1.78%
Asian	27.78%	20.63%	15.87%	17.46%	13.49%	4.76%
Hispanic	42.86%	28.57%	14.28%	3.57%	10.71%	0
White	30.51%	27.12%	14.24%	11.86%	12.20%	4.07%
Other	35.71%	28.57%	14.28%	7.14%	14.28%	0
No Answer	100%	0	0	0	0	0

Primary means of transportation	**Extremely Concerned**	**Very Concerned**	**Moderately Concerned**	**Slightly Concerned**	**Not at all concerned**	**Not sure/no opinion**
Bus	31.41%	325%	14.74%	12.18%	10.90%	5.77%
Personal Vehicle	30.74%	24.12%	18.68%	11.28%	13.23%	1.94%
Rail	35.48%	24.19%	6.45%	17.74%	9.68%	6.45%
Taxi/Rideshare	40%	20%	6.67%	13.33%	20%	0
Other	40%	36.67%	10%	6.67%	3.33%	3.33%
No Answer	0	0	0	0	0	0
Location	**Extremely Concerned**	**Very Concerned**	**Moderately Concerned**	**Slightly Concerned**	**Not at all concerned**	**Not sure/no opinion**
Rural	20.83%	30.21%	15.62%	12.5%	15.62%	5.21%
Suburban	36.15%	25.82%	13.61%	8.45%	12.68%	3.29%
Urban	34.63%	20.49%	16.58%	16.10%	8.78%	3.41%
No answer	0	66.66%	16.67%	0	16.67%	0
Education	**Extremely Concerned**	**Very Concerned**	**Moderately Concerned**	**Slightly Concerned**	**Not at all concerned**	**Not sure/no opinion**
Some High School	0	100%	0	0	0	0
High School Graduate	38.71%	22.58%	12.90%	9.68%	16.13%	0
Some college, no degree	35.06%	27.27%	15.58%	11.69%	7.79%	2.60%
College graduate	31.39%	23.30%	15.21%	11.97%	12.94%	5.18%
Postgraduate	31%	28%	16%	14%	10%	1%
No answer	50%	50%	0	0	0	0

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ACADEMIC VITA

COLLEEN MARRON

Education:

The Pennsylvania State University, University Park, PA
Bachelor of Science, Civil Engineering, May 2021
Dean's List Fall 2017 - Fall 2020
Schreyer Honors College
Thesis: Using Public Opinion to Predict Changes in Transportation Demand during the COVID-19 Pandemic
Brookfield High School, Brookfield, CT
GPA: 4.129, National Honor Society 2015-2016, Unified Sports 2015-2016, High Honor Roll 2012-2016, South West Conference All-Academic Team 2014-2016, President's Volunteer Service Award (2015), Bioethics Award (2016)

Experience:

The Pennsylvania State University, University Park, PA, Civil and Environmental Engineering, 2020-Present
- Part time grader for Fluid Mechanics Course

Skanska USA Building, New York, NY, Engineer Intern, Summer 2019 and Summer 2020
- Worked with Procurement team to organize, track, and keep contact with subcontractors working on projects in the Metro New York region.
- Assisted with the project management team on the Metropolitan Museum of Art Skylight and MEP Infrastructure Project

Panera Bread, University Park, PA, Customer Service, 2019-2020
- Work in the food production and customer service areas.

Robibero Family Vineyards, New Paltz, NY, Customer Service, 2017-2019
- Work the cash register to handle customer transactions as well as questions. When needed I label bottles and help with restocking.

Regional Hospice and Palliative Care, Danbury, CT-*Volunteer*
- Administrative Volunteer, March 2014-Present
- Lobby Greeter, March 2015-Present

Congregational Church of Brookfield, Brookfield, CT-*Volunteer*
- Yankee Fair and Barn Sale, Assistant Treasurer and Various Booths, 2009-Present (Seasonal)
- Senior Youth Mission Team, Summer 2013-2014
- Vacation Bible School, Class Assistant, Summer 2014

Leadership Activities:

BHS Dance Marathon, Brookfield High School, Brookfield, CT, Co-founder/Vice President (2013-2014) and President (2014-2016)
- Organized a 12-hour dance marathon to raise money for both the Four Diamonds Fund and Connecticut Children's Medical Center Oncology Department.

Honors and Organizations:

THON, Penn State University,
- Rules and Regulations Committee, Fundraising Specialist, 2018-2019
- Independent Dancer Couple, Chair, 2019-2020
- Dancer Relations Committee, Member, 2020-2021

Tau Beta Pi, Engineering Honor Society, Penn State University, PA, Fall 2019-present
Dear Hero Program, Penn State University, PA, Spring 2019-Fall 2019
Penn State College of Engineering, Engineering Design Spring Semester 2018 Best Overall Design

Skills and Certifications:

AutoCAD Revit Microsoft Office OSHA 10 Certification C++ and Matlab Programming