

# COVID-19 Mobility Study: Temporary and Longer-term Effects of the COVID-19 Pandemic

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Tak Chun Marcus Chan

Department of Civil and Environmental Engineering

University of California, Davis

Under mentorship from Dr. Giovanni Circella of the 3 Revolutions Future  
Mobility Program and Transportation Technology and Policy at  
University of California, Davis

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A National Center for Sustainable Transportation Research Report

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**Tak Chun Marcus Chan**, Department of Civil and Environmental Engineering, University of California, Davis

1 Shields Ave, Davis, CA 95616

(650)-307-9125

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## Introduction

The COVID-19 pandemic started in the U.S. around March 2020 and has continued to affect the lifestyle of everyone around the world. The virus is characterized by its high infectiousness and high death rate towards the older population. In many places, government acted and imposed measures in respond to the pandemic, but they differed across regions and varied between state and local governments. For example, many places announced a stay-at-home order that required all residents to stay-at-home except for essential travel. Non-essential businesses were required to shut down physical common areas and enclosed spaces. To investigate how behaviors have changed over time as a result of this pandemic and how people are adjusting to the COVID-19 impact in their lives, the COVID-19 Mobility Study was launched to better understand the temporary and longer-term effects of this pandemic on travel behaviors. The study consists of a large data collection from more than ten thousand respondents across the United States and Canada based on three versions of surveys that were administered. In the survey, we asked participants questions in regard to shifts in their travel behaviors in nine different topics such as their online and in-person shopping patterns, preferences on transportation, employment status, etc.

## Literature Review

Back in late 2019, COVID-19 is believed to be originated from Wuhan, China, and later spread to almost every country around the world. However, it was not until March that the World Health Organization (WHO) declared this virus as a pandemic (Hadi et al., 2020). In response to its high infectiousness and to protect the older population from the virus, governments around the world introduced various measures to limit contact among people. One of the most common measures is the stay-at-home order. In addition to the significant social and economic impacts the pandemic placed on the society, impact on travel behavior has also shifted in a sudden and dramatic way (Parr et al., 2020). Because of that, travel behavior in the DACH (Germany, Austria, and Switzerland) region, for example, is significantly impacted due to the increased risk projection of COVID-19 and travel risk projection. (Larissa & Roman, 2020). As trip-making behavior continues to change, it is important that the transportation policy and regulations are adjusted in accordance to realistic projections with solutions that accommodate the impact of this pandemic (Ceder, 2020).

To extend on the above literature, our researcher team at UC Davis created a comprehensive survey that contained numerous questions that would provide a better picture of an individual's temporary and longer-term activity and travel changes associated with this pandemic. Particularly, the first stage of our large data collection primarily focused on selected regions in North America. With a wide variety of questions that cover topics in social, economic, and traveling behavior, the results are believed to be useful for future transportation planning and policy making.

## Methods

The data were obtained quantitatively through three sets of online surveys. For convenience, I will refer to them as the *longitudinal survey*, the *opinion panel*, and *convenience sample*. Version 1, the longitudinal survey, had around 1,300 respondents who were resampled from a previous 2018 California mobility survey and 2019 “8 cities” transportation survey. With their information collected before the pandemic, our researchers can use these data to compare and contrast their responses. Particularly, this is a unique opportunity to observe how behaviors and attitudes have changed in response to the pandemic. In addition to these resampled respondents, Version 2, the opinion panel, is the largest data set in this study, and it consists of more than 8,800 new respondents from 15 regions in the U.S. and two regions in Canada. Lastly, Version 3 is a convenience sample that was collected by inviting participants through various channels, including social media and professional listservs. Version 3 adds about 1,300 respondents to our data set.

These online surveys had been released and responses already received when I joined the research team in June 2020. After that, in-depth data cleaning was performed to validate the responses. Invalid, offensive, incomplete, and unreasonable responses were scanned during this process. For example, respondents who live outside of North America or under 18 year-olds were eliminated from the analysis.

## Analysis Objectives

Once the data set was finalized, I have been responsible for three aspects of the data analysis: the sociodemographic characteristics of respondents, the background information of the surveyed regions, and the responses by city of selected questions from the survey. The study of sociodemographic characteristics includes distribution of age, race, gender, educational background, income level, etc. These data can be used to compare the actual sociodemographic distribution of surveyed regions and provide an important indication on the representativeness of the sample. The background information of the surveyed regions is obtained by secondary research that summarizes the political parties of their governors and mayors, as well as the government measures taken in response to the pandemic. It also includes important dates of key events such as first stay-at-home order issued, first reopening date, secondary lockdown, etc. The reopening stages, number of COVID-19 cases and gas prices at different times in each region were closely monitored. Lastly, three questions from opinion panel (Version 2) were selected to conduct deeper analysis. These questions provide a better picture on how individuals’ travel behavior and lifestyle are changed because of the COVID-19 pandemic. The rest of this report is the product of the above tasks that I believe are prominent for in-depth discussion.

# Summary of Survey Results

## Sociodemographic Data of Respondents

### Income level

One of the most important factors that can affect the results significantly is the income level of the respondents because their income is directly related to the choices they made. Having a fair distribution among all income groups can ensure the responses are reflecting the actual behaviors of the public.

In the survey, we requested respondents to report their approximate 2019 annual household income before taxes. Figure 1 shows the income distribution of all of the respondents from the three versions of data sets. The income level from \$0 to \$100K, is divided into \$25,000 increments, followed by one \$50,000 increment, then all income above \$150K. It is observed that Version 1-Longitudinal, has relatively higher percentage in the lower income groups, below \$50k, while Version 3-Social Media and Convenience, has higher percentage in the higher income groups, above \$100k. However, the biggest data set, Version 2, has the highest percentage of respondents who reported incomes in Canadian dollars. While both Version 1 and Version 3 have less than 10% on this category. When comparing the income distribution between our sample set and the 2018 US Census data, our sample sets V1-3, has more higher income samples but lack the input of lower income sample. Still, the percentages of middle class respondents (\$50k to 100k) are similar. Other than this issue, our data collection overall has a relatively even distribution that is believed to be acceptable for our research objectives.

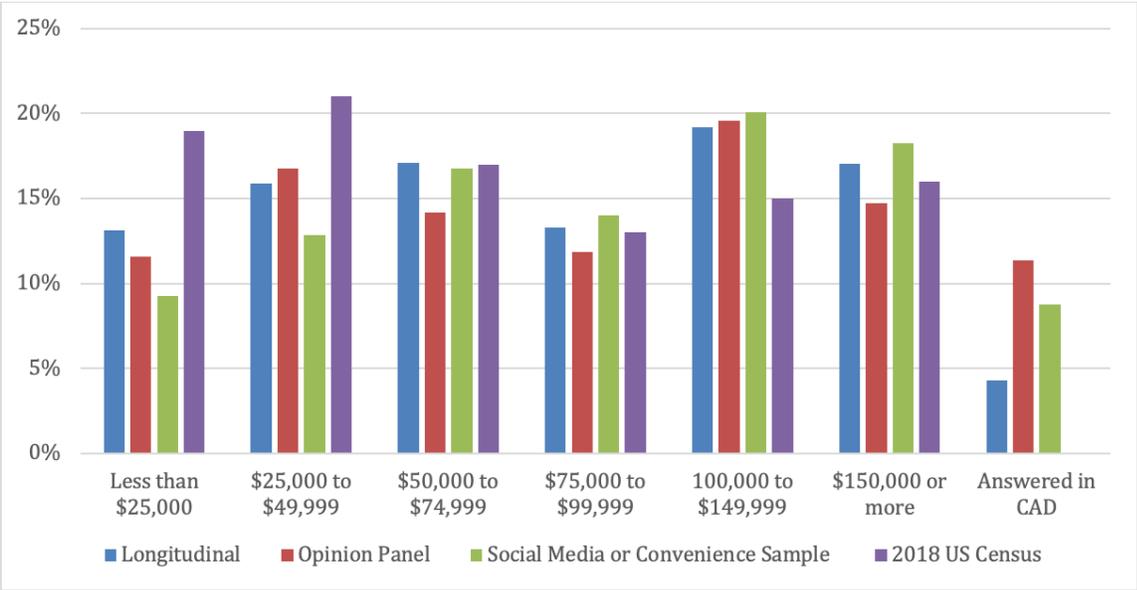


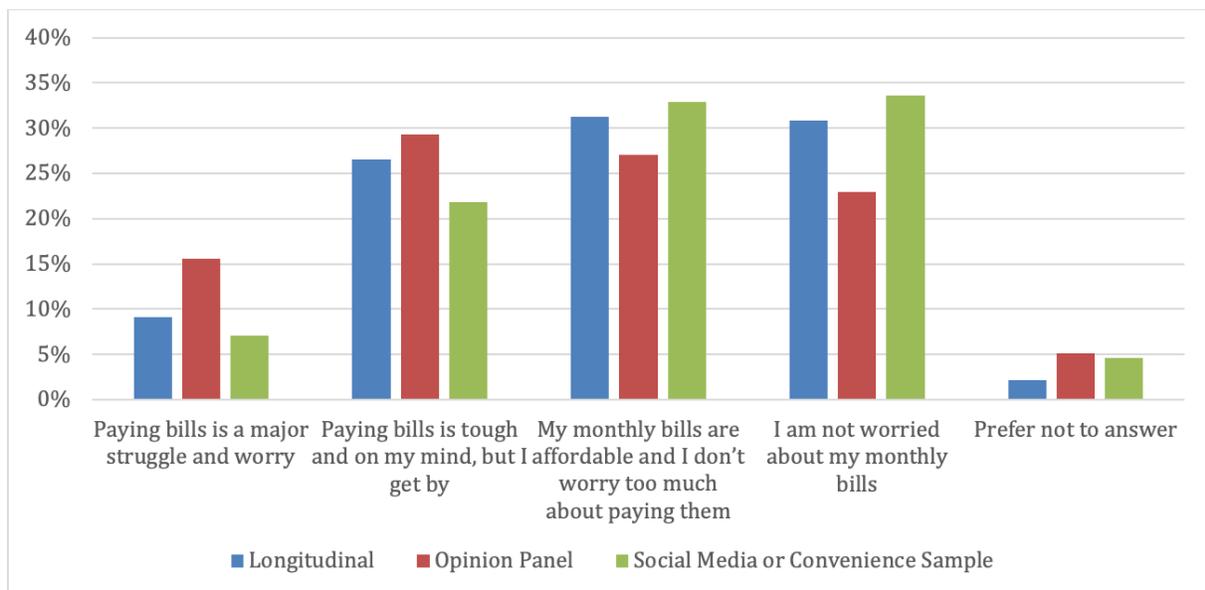
Figure 1. Income distribution of respondents across three versions (2018 US Census series source: US Census Bureau)



## Economic Situation

The COVID-19 pandemic hit the U.S. economy and resulted in high unemployment rate and a significant fall in stocks. Unemployment rate rose from 4.4% in March 2020 to 14.7% in April 2020 (“Unemployment rate rises...”, 2020). The U.S. stock market in “March 2020 made records: down 12.5% for the month, the 19th worst in history” (Jason, 2020). The annual household income that respondents provided from the previous year could not accurately describe their existing economic situation. Thus, another question was asked in a way for respondents to choose a situation that best described their conditions.

Among the four situations provided in Figure 2, nearly more than half of the respondents from all versions found monthly bills affordable. Comparing to the other two versions, Version 2 has a higher percentage showing respondents struggling in paying bills, and this correlates to its lower income level distribution as shown in Figure 1. The percent of respondents who preferred not to answer is only 5%, which is low enough that has a minor effect on our research outcomes.



**Figure 2. Economic situation distribution of respondents**

## Background Information of Surveyed Cities

### Key Dates of Government Measures

The COVID-19 timeline varies from city to city in the U.S., and the directive from the state and local governments play a significant role in managing the outbreak within their region. In general, most regions declared local emergency and announced a stay-at-home order around mid-March. The stay-at-home order required most residents to stay at home except for

essential activities such as traveling to work and visiting grocery stores. Many non-essential businesses were required to shut down physical common and enclosed workspaces. Regions began lifting their stay-at-home order in May 2020 as more non-essential businesses reopened with safety measures. Some regions also experienced or are experiencing a secondary lockdown or re-closure of dining facilities due to a rebound of COVID-19 cases. Depending on the actual situation in the region, a secondary lockdown varies from re-closing parks and trails to prohibiting indoor dining. Table 1 is a summary of dates when each city declared their local emergency, first stay-at-home order, reopening and re-closing. If the state government and local government have different dates, the stricter measure is used.

**Table 1. Summary of key dates of COVID-19 measures in various cities**

City	Declaration of local emergency	First Stay-at-Home Order	Stay-Home Order lift date	Duration of First Lockdown	Reclosure of dining facilities	Secondary restriction lift date
Kansas City	3/13	4/6	5/4	28	N/A	
Tampa	3/9	3/24	5/4	41	6/26 <sup>1</sup>	9/14
Denver	3/10	3/24	5/5	42	6/30 <sup>1</sup>	7/21
Los Angeles	3/4	3/19	5/8	50	7/13 <sup>1 2</sup>	Ongoing <sup>4</sup>
San Francisco	2/25	3/17	5/17	61	N/A	
Boston	3/15	3/23	5/18	56	N/A	
Sacramento	3/5	3/17	5/26	70	7/1 <sup>2</sup> 7/13 <sup>1</sup>	Ongoing <sup>4</sup>
Washington D.C.	3/11	3/30	5/29	60	N/A	
Detroit	3/10	3/23	6/1	70	N/A	
New York City	3/7	3/22	6/13	83	N/A	
Chicago	3/9	3/16	6/3	79	7/24 <sup>1 2</sup>	Ongoing <sup>4</sup>
San Diego	3/12	3/19	5/8	50	7/1	8/31
Atlanta	3/16	3/23	5/27	65	7/10 <sup>3</sup>	Ongoing <sup>4</sup>

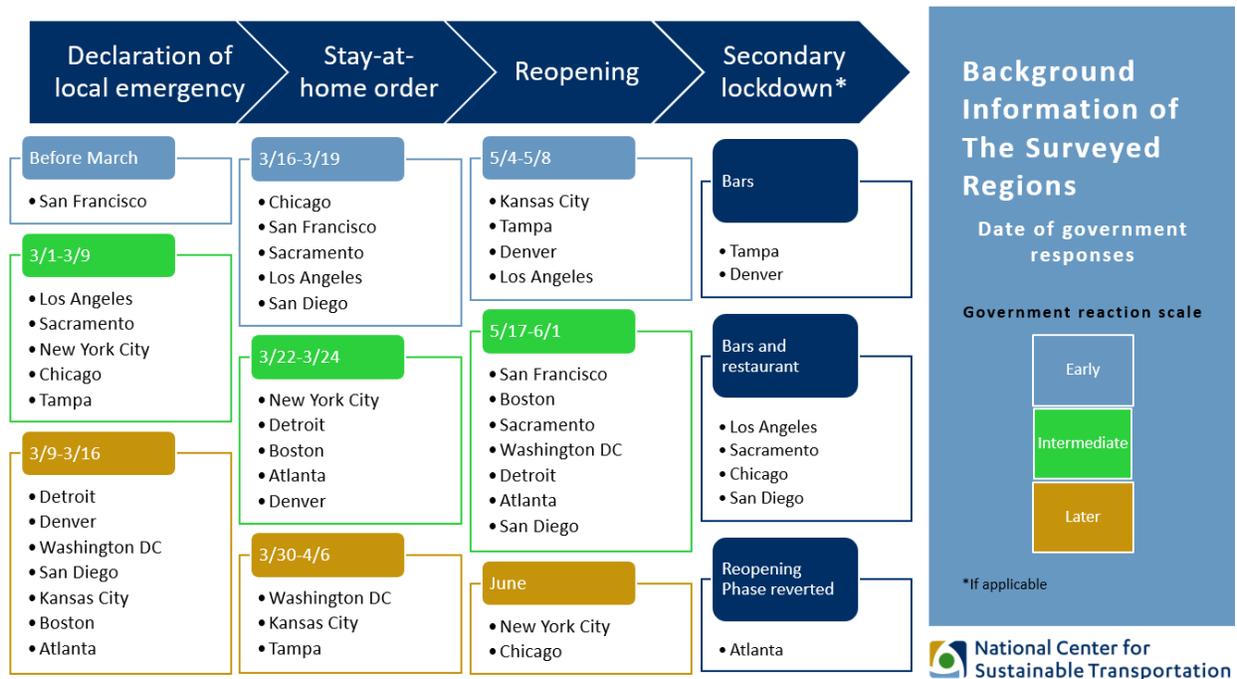
<sup>1</sup> Reclosure of bars only

<sup>2</sup> Reclosure of all indoor dining only

<sup>3</sup> Government reverted its reopening phase

<sup>4</sup> Ongoing as of Sep 10<sup>th</sup>, 2020.

The government measures in response to the COVID-19 pandemic can be summarized into a timeline with four stages as shown in Figure 3. Although there is not a clear relation showing that an earlier stay-at-home order led to an earlier reopening, it is observed that three out of the four regions that reopened early experienced or is experiencing a secondary lockdown.



**Figure 3. Timeline of the government responses in each region**

### Gas Price

Part of the survey asked respondents to provide the number of trips they travelled by category during the pandemic. Given that gas prices have been an indicator of people’s transportation behavior and demand, observing the trend of gas prices during this time could be useful for further analysis in driving-related questions.

Figure 4 shows that the gas price in all of the cities in the U.S. declined from April to May, and this is when all of the surveyed regions were implementing the stay-home order. According to the data from the U.S. Energy Information Administration, it reveals that U.S. petroleum consumption fell by 27% in April 2020 when compared to last year’s usage (Monthly Energy Review, 2020). The stay-at-home order limiting people’s travels is believed to be the biggest reason of this declination.

As some regions began to reopen in May and June, an upward trend can be seen at those times. However, not all of the regions continued to rise during the summer. In Figure 5, it is

observed that the average gas price dropped slightly in the Kansas City, Atlanta, Denver, and Detroit. Among these four cities, Detroit and Atlanta had the biggest drop. Referring to the previous section, Table 1 shows that only Detroit and Atlanta are experiencing a secondary lockdown. Although secondary lockdown could be the main factor for this, there are other minor factors that caused a slightly drop in Kansas City and Detroit.

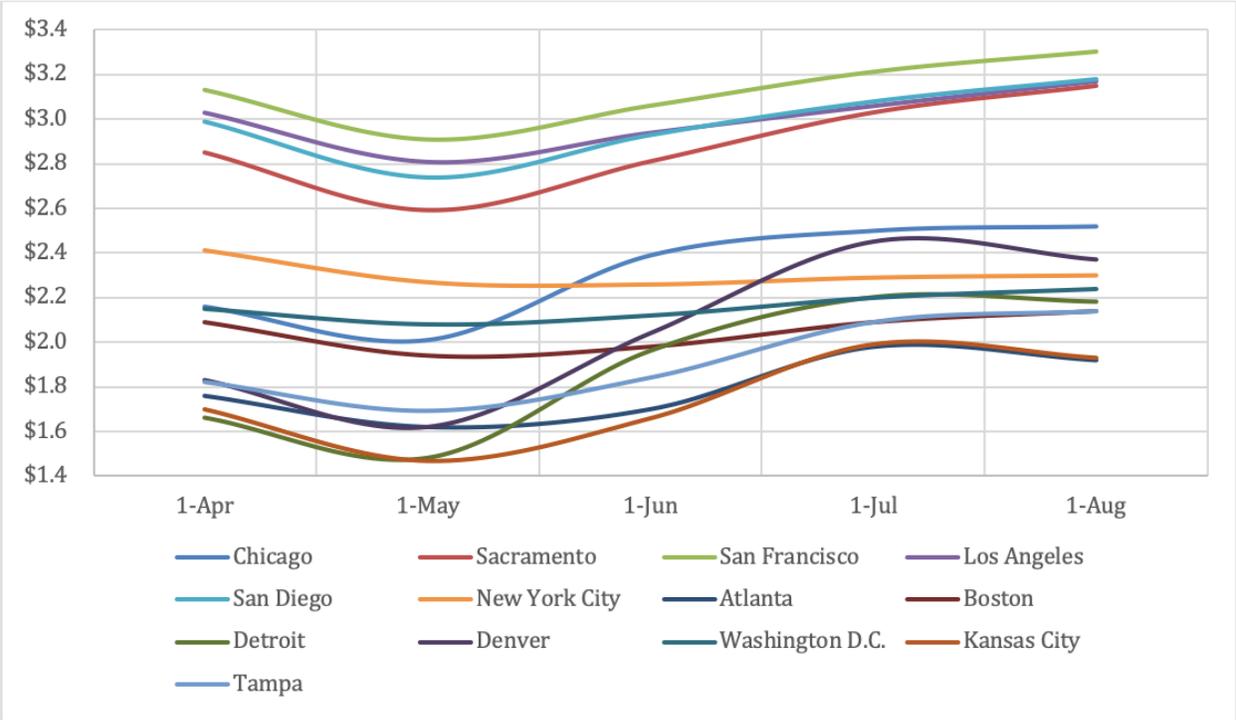
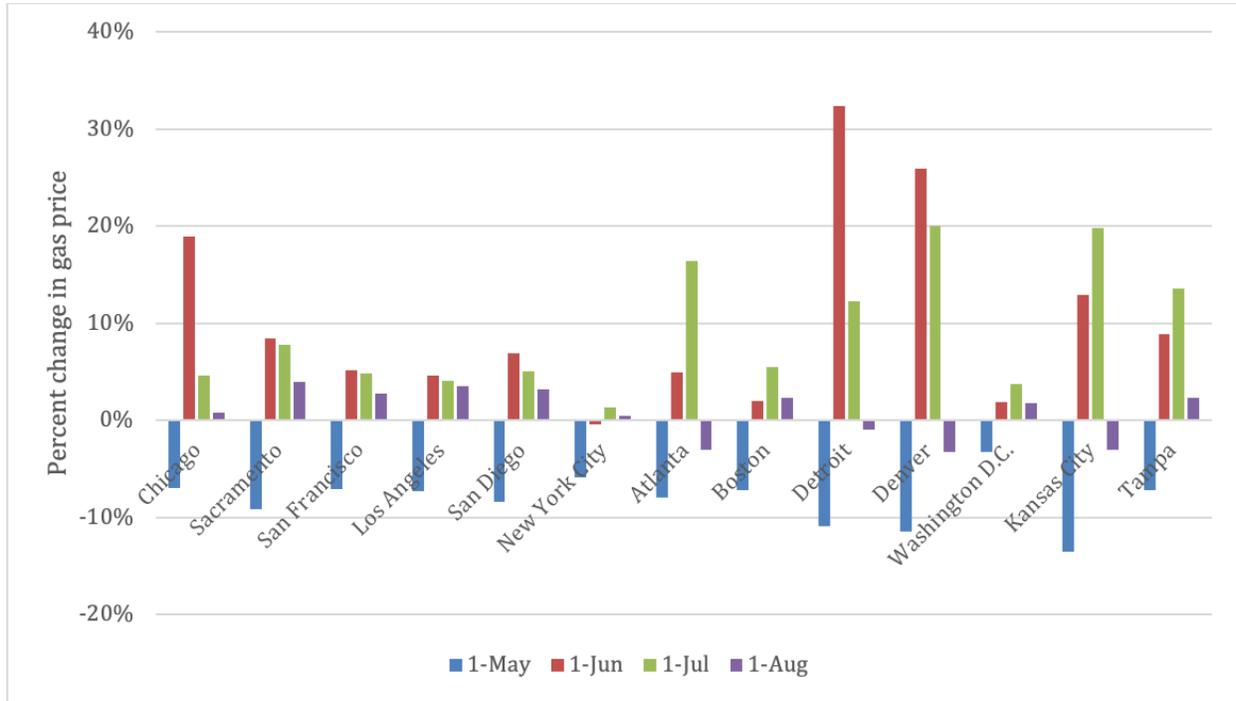


Figure 4. Average gas price in various cities during the COVID-19 pandemic

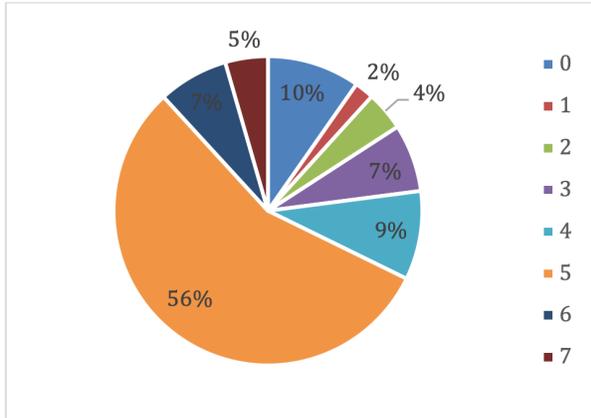


**Figure 5. Percent change in gas price in various cities during the COVID-19 pandemic**

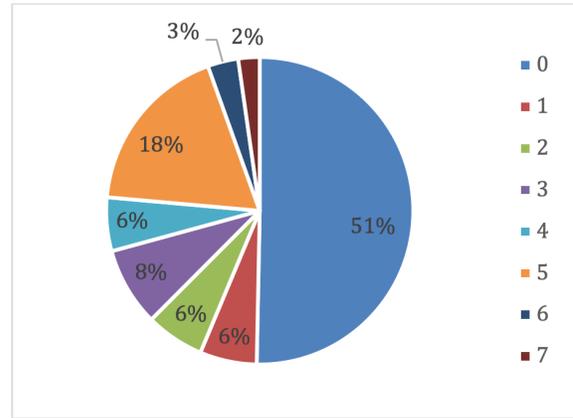
**Survey Responses of Selected Questions**

*Employment Situation Before and During the Pandemic*

To understand the commute patterns of the respondents, we asked them to provide the number of days in an average week for when they had to physically travel to work, before and during the pandemic. As mentioned in the earlier section, increase in unemployment rate and the fall of stocks are the two major economic impacts due to the pandemic. Out of the 8,354 qualifying respondents, 2,805 of them did not have a job before the pandemic, and the number rose to 3,521 respondents during the pandemic. That is, the percentages shown in Figure 6a, are represented by 4,833 responses (n=4833) while Figure 6b is based on 5,549 responses (n=5549). Before the pandemic, more than half of the respondents needed to travel for work as shown in Figure 6a. In contrast, during the pandemic, more than half of the respondents did not need to travel for work and only 18% of them still need to work five days per week as shown in Figure 6b. It is believed that these changes are due to the stay-at-home order introduced in mid-March in most surveyed regions as shown in Table 1.

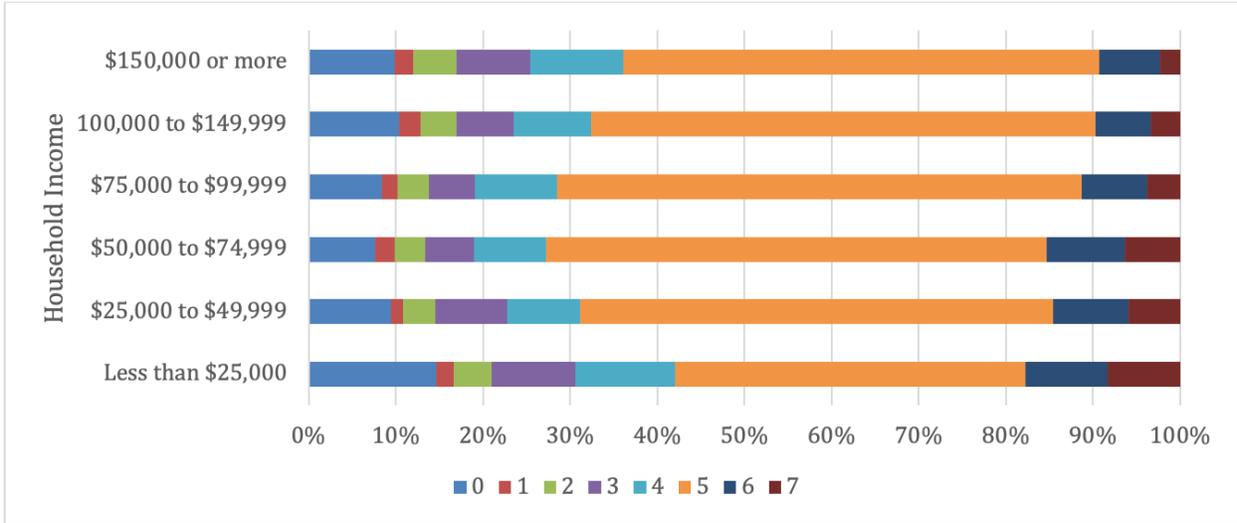


**Figure 6a. Number of days respondents had been physically traveling to work weekly before the pandemic (left)**

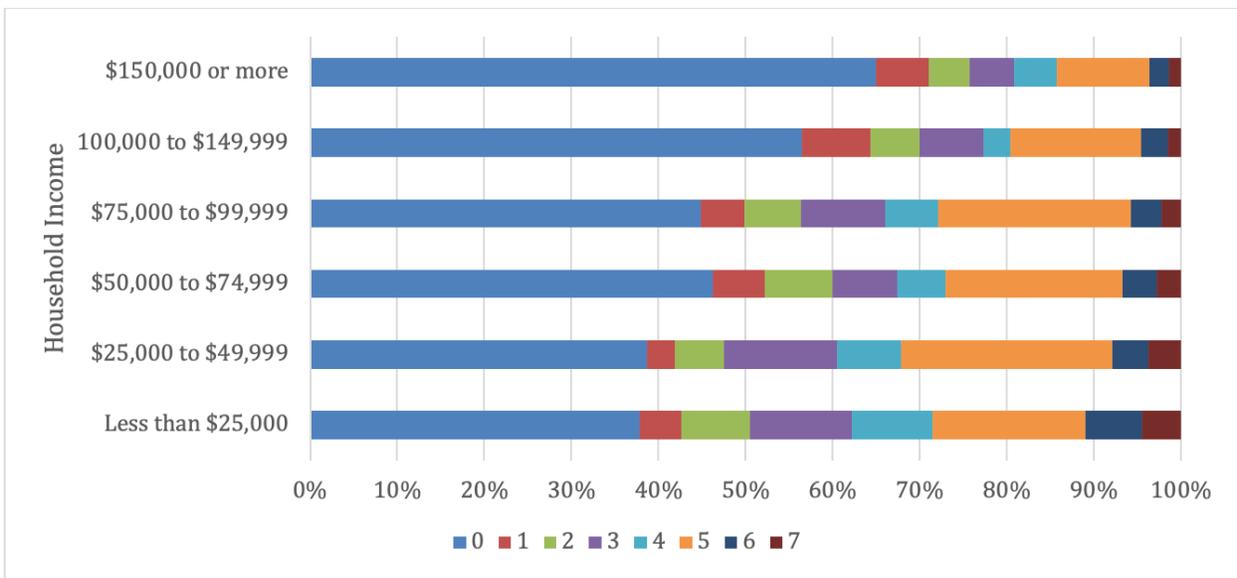


**Figure 6b. Number of days respondents had been physically traveling to work weekly during the pandemic (right)**

Figure 7a and 7b reproduces the above results by categorizing them into different household incomes. Before the pandemic, Figure 6a shows that the majority of respondents worked five or more days per week across all income levels, with the highest percentage found in middle-class. Figure 7b reveals that as income increased, workers became less likely to commute during pandemic. In fact, household income group of \$150K or more experienced the biggest shift where more than 60% did not need to commute during pandemic. The higher income group was more likely to have a job that allowed them to work remotely. However, this is not the case for low-income households as many of their jobs required them to be on-site, or they did not have access to the equipment and environment for them to telecommute.



**Figure 7a. Relationship between number of days respondents had been physically traveling to work weekly before the pandemic and their household income in percentage.**



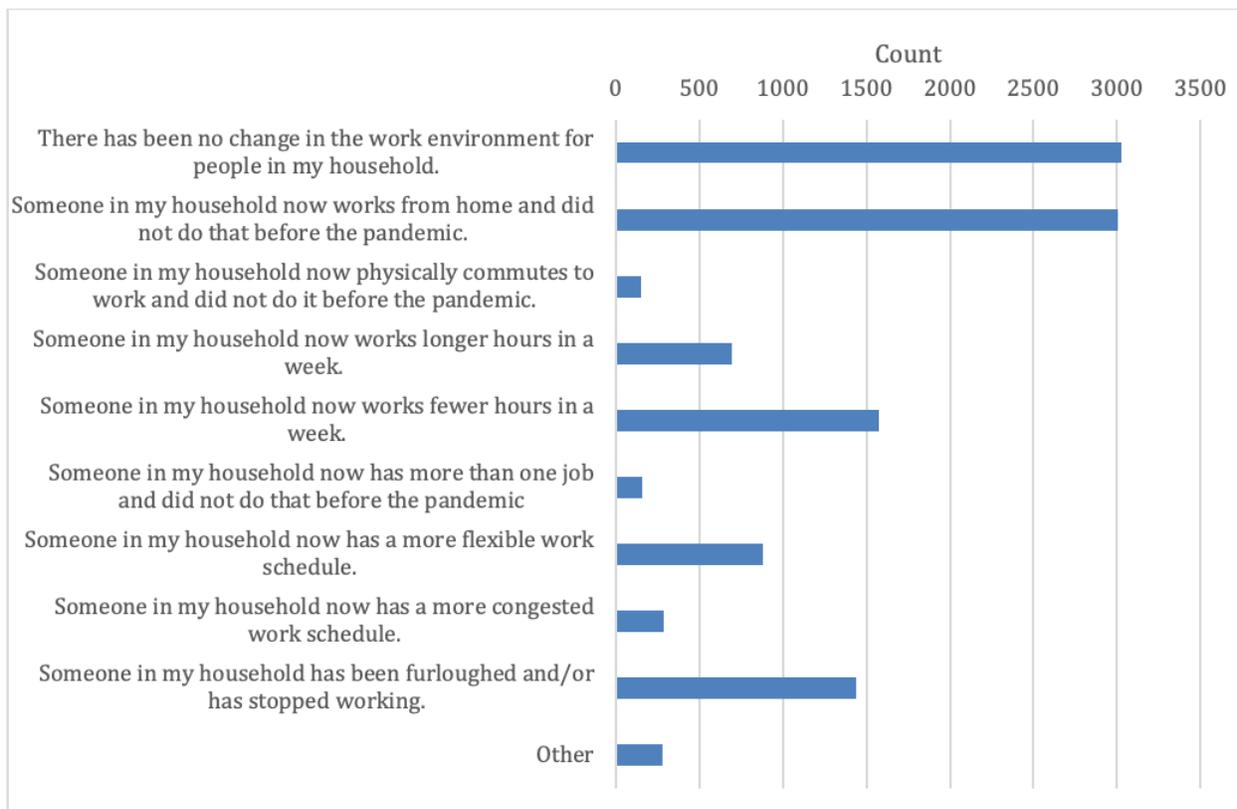
**Figure 7b. Relationship between number of days respondents had been physically traveling to work weekly during the pandemic and their household income in percentage.**

### *Work Environment During the Pandemic*

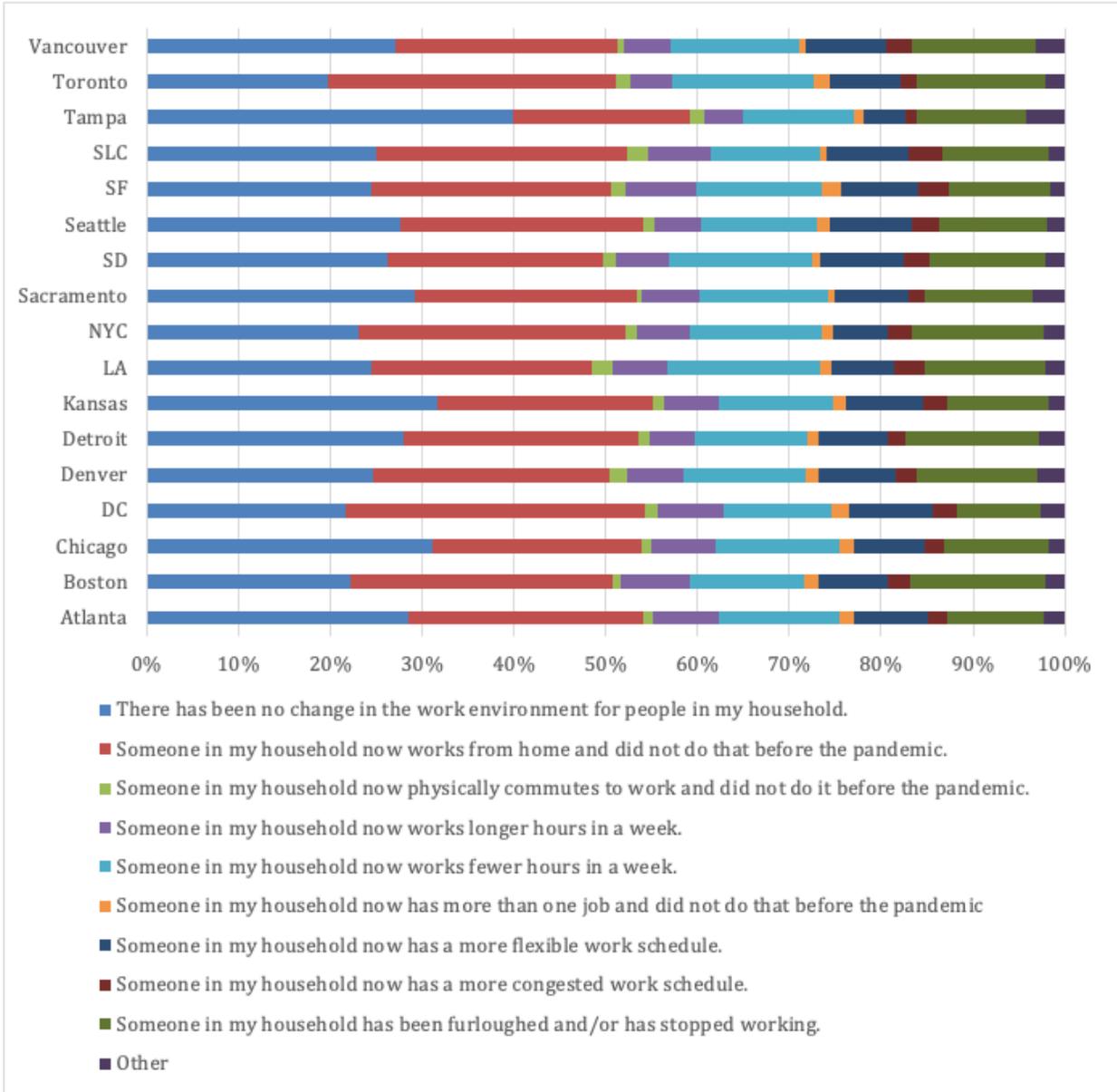
In this section, we were interested in knowing how the COVID-19 pandemic has affected the work environment of any of the employed people in their household. Specifically, in the survey, we provided 10 situations and requested respondents to check all of the situations that apply.

Among all the responses, Figure 8 indicates that Situation 1 and 2 have much higher counts than the others. Situation 1 and 2 are most likely represented by essential workers and non-essential workers, respectively. Situation 5 and 9 also receive an adequate amount of counts. They are believed to be the reason for the increase in unemployment rate and the portion of respondents who experienced financial hardship shown in Figure 2, economic situation distribution of Respondents. Situation 2 and 9 could likely be the reasons of the fall in gas price that is mentioned earlier.

Figure 9 shows that most regions in North America experienced a similar distribution of these situations. Among all the regions, Tampa has the highest percent for Situation 1 and Washington D.C. has the highest percent Situation 2.



**Figure 8. Number of Respondents experienced changes in work environment due to the pandemic**

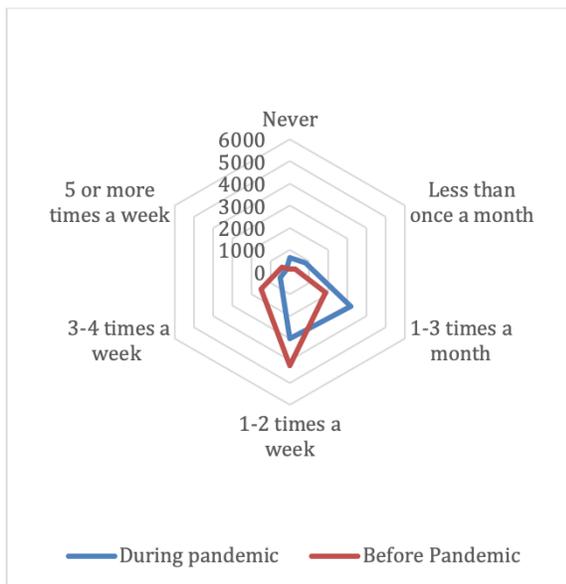


**Figure 9. Percentage of respondents experienced changes in work environment by regions due to the pandemic**

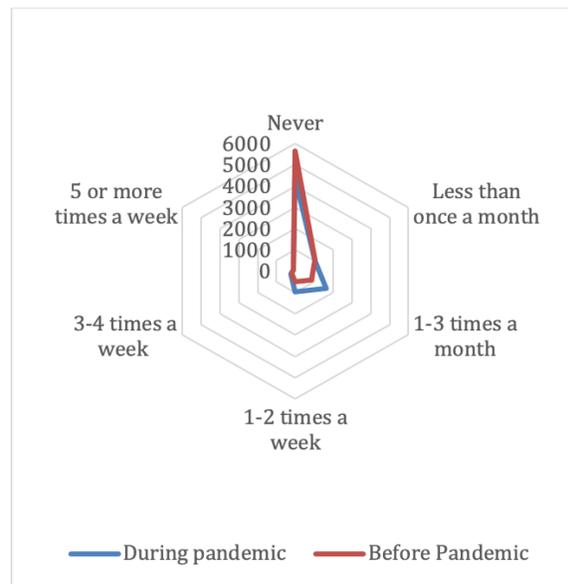
*Shopping Habits During the Pandemic*

Visiting grocery stores have been a tradition for most people before the pandemic although online grocery shopping services have been in the market for some time. Although most grocery stores remained open during the pandemic, many were hesitant to visit because of the higher risk of exposure to the virus. In this section, the frequency and mode of grocery

shopping are shown in Figure 10a and Figure 10b. Figure 10a shows that people are reducing their visit to grocery during the pandemic. Before the pandemic, most of the respondents used to visit grocery stores 1-2 times a week. However, during the pandemic, many of them only visited 1-3 times a month instead. Other than reducing the frequency of going to grocery stores, online shopping is also an alternative for a safer and more convenient way to get groceries. Figure 10b shows that online grocery shopping has gained popularity with more than a thousand of our respondents becoming first-time users in online grocery shopping during the pandemic. Still, this is not a very common way of buying groceries, and for those who developed this habit, they did not shop as frequently as they would have for in-person shopping. Online grocery shopping has its limitations. For instance, buyers cannot get the items immediately and the expected condition or freshness of the item is not always guaranteed.



**Figure 10a. Count of respondents visit grocery stores in different frequency before and during the pandemic (left)**



**Figure 10b. Count of respondents purchase grocery items online in different frequency before and during the pandemic (right)**

## Potential for Further Research

Given that the COVID-19 pandemic is an on-going event, it is important for our research team to continue data collection as the pandemic evolves. Many regions have been experiencing reopening, secondary and subsequent lockdown, and it seems like this cycle will be the “new” normal for many of us. As more regions enter the reopening stage, it is an opportunity to observe new trends and behaviors. Secondly, our future research should target low-income households because the income distribution of our sample leans toward the higher income groups when comparing to the Census data as mentioned in an earlier section. Other ideas

include diving deeper into logistical transportation and expanding the study region internationally.

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