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Long-Haulers and Labor Market Outcomes

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Abstract

There have been growing concerns about long-haulers or individuals with long-term COVID-19 health complications (long-haul COVID). While the medical field has been investigating the health complications, there has been limited research on the relationship between long-haul COVID and labor market outcomes. To investigate this relationship, I used the University of Southern California Understanding America Study COVID-19 longitudinal survey to provide a snapshot of mid-2021. I first find about 24.1% of individuals who have had COVID are long-haulers and 25.9% of long-haulers reported that their long-haul COVID affected employment or work hours. I then find that a majority of these affected long-haulers remained employed and in same employment type. But I find that their mean change in work hours and paycheck declined. Afterwards, I tested whether long-haul COVID is associated with negative changes in labor market outcomes. When I combined long-haulers who reported that their health complications did or did not affect work, I failed to find that long-haulers are less likely to be employed relative to individuals without prior COVID infection. But, when I discern long-haulers by whether long-haul COVID affected work, I find that long-haulers who reported long-haul COVID affected work are 10 percentage points less likely to be employed and, on average, work 50% fewer hours than individuals without prior COVID infection. In contrast, I failed to find evidence that affected long-haulers receive a lower paycheck earning relative to individuals without prior COVID infection. Lastly, when comparing these affected long-haulers against similar individuals, I find evidence that they are more impacted in their employed status and work hours. Due to limitations, future data collection and research would provide a more robust picture.

JEL Codes: J2, I12

Key words: long-COVID, labor market outcomes

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1 Introduction

There have been growing concerns about "long-haulers" or individuals with long-term COVID-19 health complications (long-haul COVID). Anecdotally, some long-haulers have been unable to perform simple everyday tasks, such as standing up (Belluck, 2020). Some have even mentioned changing jobs to balance their health and work (Doughton, 2021). Given these anecdotes, there has been growing discussion about the impacts of long-haul COVID possibly contributing to the COVID pandemic labor shortage (Bach, 2022).

While the medical field has been investigating long-haul COVID complications and the prevalence of long-haulers, to the best of my knowledge, there has been limited research on the relationship between long-haul COVID and labor market outcomes. Davis et al. (2021) is among the few but growing number of studies that have looked into this relationship. Using survey data, Davis et al. (2021) finds that 23.3% of their sample reported that their health complications caused them to not work. Other reports and papers, such as such as Aiyegbusi et al. (2021), Vanichkachorn et al. (2021), and Trades Union Congress (2021), find similar results of long-haulers reported difficulty working. There is now growing research trying to identify causal effects of long-haul COVID on work performance. An example is Fischer et al. (2021) using differences-in-differences to analyze whether the impacts of long-haul COVID on soccer players' ability to perform in matches.

Building upon the literature, this paper uses University of Southern California (USC)'s US-representative longitudinal data, Understanding America Survey (UAS) COVID survey (2020-2021), to provide more information on the relationship between long-haul COVID and labor market outcomes in mid-2021. The benefit of using UAS is the longitudinal nature of the data. For each respondent, I am able to track all *reported* labor market outcomes, health outcomes, and other characteristics over time. In addition, UAS is a nationally representative survey and provided information on individuals who were diagnosed, tested, and believed with COVID.

In this paper, I studied this relationship by answering four main questions. Firstly, I looked at the prevalence of COVID and long-haul COVID. I find that 24.1% of individuals who have had COVID are long-haulers. Secondly, I looked at the prevalence of long-haulers who reported that their persistent COVID-related health complications affected employment or work hours. I find that 25.9% of long-haulers indicated that their persistent COVID health complications affected employment or work hours. Thirdly, I focused on measuring the severity of long-haul COVID by looking at the proportion of affected long-haulers who remained employed and same type of employment and the mean decline in work hours and

paycheck. Among affected long-haulers who started as employed in the longitudinal data, a majority indicated staying employed and remained in the same employment type. I then find a decline in mean change in work hours and paycheck amount for affected long-haulers. Lastly, I tested whether long-haul COVID is associated with negative changes on selected labor market outcomes using four ordinary least squares (OLS) regressions. I failed to find that long-haulers are less likely to be employed relative to individuals who have not had COVID when combining long-haulers who reported that long-haul COVID did or did not affect work. After separating long-haulers by whether their health complications affected work, I find evidence that long-haulers who reported their health complications affect work are 10 percentage points less likely to be employed and, on average, work 50% less hours than individuals without prior COVID infection. But, I failed to find evidence that these affected long-haulers receive a lower paycheck amount relative to individuals without prior COVID infection. When comparing these affected long-haulers against similar individuals, I find evidence that affected long-haulers are more impacted in their employed status and work hours. Due to limitations, future data collections and studies would provide more information about the relationship between long-haul COVID and labor market outcomes.

This paper delves into four sections. Firstly, I provide a brief background information on COVID-19 in Section 2. Then, in Section 3, I proceed to provide a summary about UAS survey, the fielded questions and results, procedure to prepare data, definitions that I used for the rest of this paper, and procedure to make calculations for descriptive statistics and analysis. Afterwards, I provide descriptive statistics and test whether long-haul COVID is associated with negative change on selected labor market outcomes in Section 4. Lastly, I summarizes results and discusses limitations in Section 5.

2 Background

In February-2020, the World Health Organization (WHO) announced that a virus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), caused coronavirus disease, or COVID-19 (World Health Organization, 2020-2021).[1] COVID symptoms included fevers, "new loss of taste or smell," fatigue, and other symptoms (CDC, 2020-2021b). WHO announced, a month later, that the COVID outbreak as a pandemic (Cucinotta and Vanelli, 2020). In 2021, other COVID variants, such as Delta and Omicron variants, were identified (Centers for Disease Control and Prevention, 2020-2022).

[1]For the rest of this paper, I will refer COVID-19 as COVID.

While those who tested positive for COVID have symptoms lasting a few weeks, there have been cases of those who have persisting COVID health complications. These individuals have been called "long-haulers." Currently, medical experts are still investigating long-haul COVID. Hence, to the best of my knowledge, there is no "standardized definition" at the moment (CDC, 2020-2021c). From current research, the medical research literature has categorized long-haul COVID into two types. According to Nalbandian et al. (2021), there are "ongoing symptomatic COVID" and "post-COVID" symptoms. Some of these symptoms included brain fog, muscle pain, and other health-related complications (CDC, 2020-2021a). For the first type, medical experts have defined these symptoms to last between 4 to 12 weeks. For the second type, these symptoms lasted at least 12 weeks (Nalbandian et al., 2021). For this paper, I focus on the latter (or most conservative category) of at least 12 weeks since being infected.

3 Survey Data

3.1 Background

I used the University of Southern California (USC) 's Understanding America Study (UAS) COVID survey data. This survey is a high-frequency US-representative longitudinal data. UAS started in March-2020 and been fielded every 14 days. After the March-2020 survey wave, surveys were fielded for 28 days. For detailed information about the survey, please see Kapteyn et al. (2020).

There are three benefits for using UAS. Firstly, UAS longitudinal data allowed me to track the entire history of a respondent's reported labor market outcomes, such as labor status and work hours. So, I was able to calculate the changes in labor market outcomes. Secondly, the data is nationally representative. Thirdly, UAS asks respondents whether individuals were diagnosed with, tested for, or believed to have had COVID. This captured both hospitalized and non-hospitalized COVID individuals.

Since, to the best of my knowledge, there has been minimal detailed data collection on long-haulers and their labor market outcomes, I proposed questions to identify long-haul COVID and their labor behavior to the USC UAS. Table 1 displays the fielded questions. The UAS field the newly proposed questions for UAS 346 survey wave 28 (or survey wave 28) from May 12, 2021 to June 22, 2021. During this time, UK, Brazil, and South Africa variants were identified (Centers for Disease Control and Prevention, 2020-2022). Delta variant was first identified during the later half of survey wave 28 and Omicron variant was not identified

yet (Centers for Disease Control and Prevention, 2020-2022).

Table 2 displays the results. 793 of the respondents indicate ever having COVID. Among these 793 respondents, 193 respondents are "long-haulers" or those with COVID-related complications or symptoms that exceed at least 12 weeks. 95 long-haulers have indicated recovering while 60 suggested COVID-related complications affected employment status or work hours. Due to the small number of long-haulers in the sample, I do not look into demographics cuts.

Table 1: Long-Term COVID-19 Survey Questions

Category	Question
Identifying Individuals Who Have Had COVID	Since the start of the pandemic, have you ever become infected with COVID-19?
Identifying Individuals Who Have Had Long-Term COVID	Did you have COVID-related symptoms or health complications that lasted at least 12 weeks?
Identifying whether Long-Term COVID Affected Employment or Work Hours	Did your COVID-related symptoms or health complications affect your employment status or work hours?
	When did your COVID-related symptoms or health complications affect your employment status or work hours? If you're not sure, just give your best guess.
Identifying Recovery Among Long-Haulers	Have you recovered from your COVID-related symptoms or health complications?
	When did you recover? If you're not sure, just give your best guess.

Note: Questions were fielded in UAS 346 Wave 28 from May 12, 2021 to June 22, 2021.

Table 2: Sample Size in UAS 346 Wave 28

	Have Not Had COVID	Ever Become Infected	Had COVID Complications Or Symptoms for 12+ Weeks (Long-Haulers)	Long-haulers with COVID-related Health Complications Affected Employment Status or Work Hours	Long-haulers who Recovered From COVID-related Health Complications
Child					
No Children/Not Responded	3,966	581	144	47	75
Have Children	1,019	212	49	13	20
Total	4,985	793	193	60	95
Race					
White	3,860	648	161	45	75
Black	406	40	8	3	6
American Indian/Alaska Native	86	34	10	7	6
Asian	304	22	5	2	4
Hawaiian/Pacific Islander	34	4	–	–	–
Mixed	266	37	7	3	4
Total	4,956	785	191	60	95
Age Group					
18 To 25 Years	149	40	8	4	3
25 To 29 Years	228	52	13	5	10
30 To 34 Years	348	79	20	7	11
35 To 44 Years	890	164	41	11	12
45 To 54 Years	864	187	50	16	22
55 To 64 Years	1,069	140	30	11	18
65 To 74 Years	1,002	103	23	5	15
75 Years and Older	435	28	8	1	4
Total	4,985	793	193	60	95
Education					
Less High School	207	41	11		7
High School	786	114	32	8	14
Some College	1,748	329	81	32	40
College	1,274	185	39	11	20
Post College	970	124	30	9	14
Total	4,985	793	193	60	95
Married /With Partner					
Yes	3,188	538	124	38	59
No	1,795	255	69	22	36
Total	4,984	793	193	60	95

Note: Questions were fielded in UAS 346 Wave 28 from May 12, 2021 to June 22, 2021. Some of the respondents did not provide information about their race or marital status. All respondents are at least 18 years old. **Source**: USC UAS.

3.2 Outliers and Missing Data

To prepare data for descriptive statistics and analysis, I addressed misreporting and missing data. For misreporting, two long-haulers reported that they started to be affected in November and December-2021 while reporting recovering in 2020. I assumed these individuals meant to select 2020, so I recoded these two cases from 2021 to 2020.

I then proceeded to address missing data. I first addressed the five long-haulers who reported that long-haul COVID affected work prior to the start of the survey data (March-2020). For these few cases, I used the nearest observations of a respondent's first participated wave on or after March-2020 information. Afterwards, I addressed the one respondent who indicated being a long-hauler but did not report the starting date. I excluded this respondent when analyzing the mean change in work hours and paycheck amount. Lastly, I addressed missing data for labor status, employment type, work hours, paycheck amount, and selected demographic characteristics.

- **Labor Status**: UAS classified labor status as "currently working," "on sick or other leave," unemployed ("looking for work or temporary laidoff"), retired, not in the labor force or unknown (UAS, 2020-2022). For labor status, a few respondents who refused to answer. Only about 1.6% of all pooled respondents are missing labor status and 5.7% of all pooled respondents are missing employment type.[2] In this case, I assumed that a respondent's labor status did not change, so I used information from available survey waves using the following procedure. Firstly, I used the next survey wave labor status. If the reported labor status is still missing, then I used the previous survey wave labor status. Secondly, if the respondent only participated in one survey wave or refused to provide his/her labor status for all participating survey waves, I excluded this respondent when preparing calculations.

- **Employment type**: employment type is defined as a respondent who reported being employed and is either self-employed or working for an employer. Employment type is not available for the first survey wave. So I used the next available survey wave reported employment type to substitute for the missing first survey wave. If employment type is missing despite the respondent reporting being employed, I used the same method I employed when imputing labor status.

- **Work Hours and Paycheck Amount**: there are two cases of missing data for work hours and paycheck amount. The first case included individuals who are not working

[2] I define all pooled survey waves as survey waves 1 to 28.

(retired, unknown, unemployed, not in the labor force) or currently sick. I replaced both variables with zero if the labor status is not "currently working" or not "on sick or other leave" (UAS, 2020-2022). After employing this method, only about 1.7% of work hours and 3.0% of paycheck amount are missing within the pooled sample of all respondents. I would like to note that the paycheck amount was not asked in the first survey wave, so I used the nearest observation before executing the two cases procedure. The second case involved missing data from refusing or not answer the survey question even though they reported working during that survey wave. In this case, I took the median value within each survey wave by age group, education group, and labor status.[3] If still missing, I took the median value across all pooled survey waves by age group, education group, and labor status. Afterward, I used the median value among all of a respondent's reported information if there are still missing cases. If the respondent did not report in one survey wave, I used the nearest observation. Lastly, if the respondent did not report any throughout their participated survey waves, I excluded them in my later analysis.

- **Demographics**: demographics included age groups, education groups, race, gender, marital status (married or otherwise), and school-aged children status (have at least one child in elementary, middle, or high school or none). I used the same age groups and education groups used when imputing for work hours and paycheck amount. I used the race variable where the characteristics included Black, American Indian and Alaska Native, Asian, Hawaiian and Pacific Islander, Mixed, or White (UAS, 2020-2022). For gender, I used the gender variable that included female or male. For marital status, I used the married variable that included married (lives with a spouse or elsewhere), separated, divorced, widowed, or never married (UAS, 2020-2022). Except for school-aged children status, I addressed missing data as the following: I first used the next survey wave reported demographic characteristics. If the characteristic was still missing, I used the previous survey wave reported characteristic. I used a different procedure to determine the status of school-aged children. I first used `totalk12` variable, which provides information on "the number of children in elementary, middle or high school" for only selected survey waves (UAS, 2020-2022). Assuming the number of children does not change, I used the nearest survey waves reported number of school-aged chil-

[3]The age group consisted of 18 to 25, 25 to 29, 30 to 4, 35 to 44, 45 to 54, 55 to 64, 65 to 74, and 75 years and older. All respondents are at least 18 years old. The education group consist of completed less than high school, high school, some college, college, and post-college, such as graduate school. For labor status, I used the imputed labor status that was discussed previously.

dren. Then I determined whether the respondent had at least one school-aged child or none. When testing regressions, I excluded individuals who have missing at least one demographic characteristic.

3.3 Definition of Groups

To determine the severity of the relationship between long-haulers and their labor market outcomes and test the relationship between long-haul COVID and labor market outcomes, I used four groups as a comparison. The four groups included (1) *"healthy"* individuals, (2) affected long-haulers, (3) unaffected long-haulers, and (4) non-long-haulers. The first group consisted of individuals who have not had COVID. The second group included affected long-haulers who reported that their health complications impacted their employment or work hours. Group three included long-haulers who indicated having long-haul COVID but they reported that their health complications did not impact work. The final group consisted of individuals who have had COVID but COVID lasted less than 12 weeks.

3.4 Calculations

For both descriptive statistics and regressions, I only focused on a subset of UAS longitudinal data. Since questions identifying whether a respondent have had long-haul COVID are only in survey wave 28, I excluded respondents who participated in other survey waves except survey wave 28. Within this subset of the UAS longitudinal panel, I tracked each respondent's imputed survey answers across all participating survey waves to construct base and affected measurements.

3.4.1 Descriptive Statistics

When looking at the relationship between long-haul COVID and labor market outcomes, I first looked at the proportion who remained employed, proportion who remained in same employment type, and the duration of inability to work. To measure the severity of long-haul COVID, I calculated the mean change in "work hours in past seven days" and "most recent paycheck" by group (UAS, 2020-2022). In preparation, using the defined groups, I used the following procedure:[4]

[4]Please see Appendix 6.2 for detailed description about the calculation process.

- % **Remained Employed**: I calculated the percentage change in *base* period labor status and *affected* period labor status conditional on individuals who reported to work at the beginning. I identified the *base* and *affected* labor status based on three cases:
  - **Healthy Individuals**: *base* labor status is first reported labor status and *affected* labor status by taking last reported labor status. There are a few cases where the respondent who do not report their labor status, so I excluded them in the calculations.
  - **Affected Long-haulers**: I identified *base* labor status by taking the labor status in the survey prior to the first time the respondent reported having COVID. For respondents who did not report having COVID but indicated specific month and year when long-haul COVID affected employment or work hours, I used the reported labor status in the nearest wave. *Affected* labor status is the labor status in the latest survey wave of the respondent having long-haul COVID. There are a few cases where the respondent does not participate in the survey when he/she first reported being sick or having long-haul COVID symptoms, so this respondent was not captured in this particular calculation.
  - **Non-long-haulers**: I used similar methodology used for *affected long-haulers*.
- % **Remained Same Employment Type**: I used a similar method as applied when calculating *% remain employed*. Since the employment type was not asked in the first UAS survey wave, I used the next reported employment type in the first survey wave if a respondent reported working in the first survey wave.
- **Duration of Having Long-Haul COVID Impacting Employment or Work Hours**: I only focused on *affected long-haulers*. Since I do not have the exact date, I assumed that the duration occurs throughout the *entire* month. I defined the start of having COVID when respondent indicated the specific month and year. I defined the end of the duration of having COVID if the respondent indicated recovering from COVID. If a respondent did not indicate recovering from COVID, I substituted the end of the duration with June-2021.
- **Mean Change in Work Hours**: I used the number of "work hours in the past seven days" (UAS, 2020-2022). I identified the *base* period and *affected* period work hours in my subset. Then I calculated the difference for each respondent and then took the mean by group. *Base* and *affected* work hours were identified by four groups:

- **Healthy Individuals**: the *base* number of work hours is the amount in the first participating survey wave. *Affected* work hours is the last reported number of work hours.
- **Affected Long-haulers & Unaffected Long-haulers**: the *base* number of work hours is the mean amount across survey waves prior to the survey wave that the respondent first indicated having COVID from a test, diagnosis, or belief. *Affected* work hours is the mean work hours during the period of reported having long-haul COVID.
- **Non-long-haulers**: *base* work hours is the mean amount across survey waves prior to the survey wave that the respondent first indicating having COVID from a test, diagnosis, or belief. *Affected* work hours as the mean work hours across all survey waves who reported having COVID.

- **Mean Change in Paycheck**: I used the "most recent paycheck" amount (UAS, 2020-2022). Using Federal Reserve Bank of St. Louis FRED's *US Bureau of Labor Statistics Consumer Price Index (CPI) for All Urban Consumers: All Items in US City Average*, I converted the paycheck amount to 2019 real dollars (U.S. Bureau of Labor Statistics, 2020-2021). I used the same steps used to calculate the *change in work hours*.

3.4.2 Regressions

To test whether long-haul COVID has a negative association on selected labor market outcomes, I calculated three groups of variables within my subset for all four regressions. I used the following procedure:[5]

- **Base Outcomes**

1. **Employed**: to identify the *base* period labor status by group, I used the same methodology when identifying *change in employment*. Then I coded whether the *base* employment is "currently working" or otherwise ("on sick or other leave," unemployed, retired, not in the labor force, or unknown) (UAS, 2020-2022).
2. **Natural Log of Work Hours and Paycheck**: I identified *base* period mean work hours and paycheck by group using the same methodology when identifying the *mean change in work hours or paycheck* except for calculating the mean by

[5]Please see Appendix 6.3 for detailed description about the calculation process.

group. Instead, I took the natural log of *base* work hours and paycheck amount for each respondent.

- **Affected Outcomes**

    1. **Employed**: I identified the *affected* labor status by group by using the same methodology when identifying the *change in employment*. Then I coded whether the *affected* employment is "currently working" or otherwise ("on sick or other leave," unemployed, retired, not in the labor force, or unknown) (UAS, 2020-2022).
    2. **Natural Log of Work Hours and Paycheck**: I identified the *affected* mean work hours and paycheck by group using similar methodology when identifying the *mean change in work hours or paycheck* except for calculating the mean by group. Instead, I took the natural log of *base* work hours and paycheck amount for each respondent.

- **Controls - Demographic Characteristics**: to control for respondent's characteristics, I used the following demographic characteristics

    1. **Age Groups**: age groups included 18 to 25, 25 to 29, 30 to 34, 35 to 44, 45 to 54, 55 to 64, 65 to 74, and 75 years and older. All respondents are at least 18 years old.
    2. **Education Groups**: education groups are completed less than high school, high school, some college, college, and post-college, such as graduate school.
    3. **Marital Status**: marital status is a dummy variable where I indicated whether or not the respondent was married.
    4. **School-Aged Children Status**: school-aged children status is a dummy variable where I indicated whether or not a respondent has at least one school-aged child.
    5. **Race**: race groups included White, Black, American Indian and Alaska Native, Asian, Hawaiian and Pacific Islander, and Mixed (UAS, 2020-2022).
    6. **Gender**: gender is a dummy variable on whether a respondent is a male or female.

4 Results

4.1 What Proportion has had COVID & Long-Haul COVID?

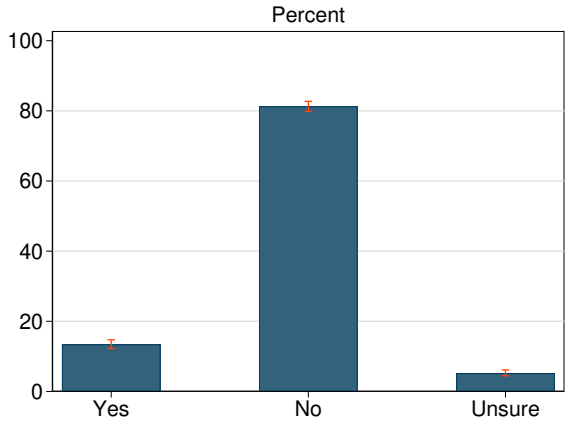
First, there is a question of what percentage has had COVID and, specifically, has had long-haul COVID. Figure 1 showcases the proportion of individuals who have had COVID and long-haul COVID.[6] I find that 13.4% have had COVID in mid-2021. There might be a question of whether my calculation is underestimated or overestimated. Using the US Census Bureau's Household Pulse Survey (HPS) as a benchmark, I find that my calculated share is near the HPS range of 13.7% in May-2021 and 13.9% in June-2021 (Okoro and Wozniak (2022), US Census Bureau (2020-2022)).[7] I would like to note that HPS only asked about COVID diagnosis and does not ask about tested and belief of having COVID, so our estimates will differ.

Among those who have COVID, the majority indicated having no persistent COVID-related health complications for at least 12 weeks. Only 24.1% of COVID-infected individuals are long-haulers in mid-2021. When looking among long-haulers, 49.9% have indicated recovering from persistent COVID health complications. In contrast, 36.8% of long-haulers indicated not recovering. The shares of reported COVID and long-haul COVID are within the range of another study, Chen et al. (2022), pooled estimates of 25% at 60 days and 32% at 90 days. The UAS share of long-haulers is slightly lower than that of the pooled estimate of 31% for the US. I would like to note Chen et al. (2022) mostly used studies that sampled in 2020 and used different questions to determine whether an individual is a long-hauler so the prevalence will differ from my UAS estimate.

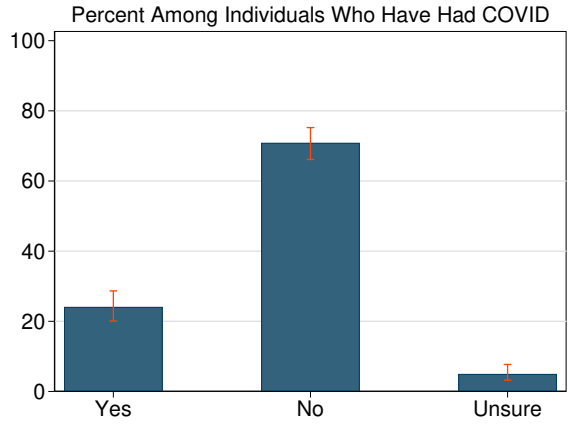
[6] Please see table 6 for the proportion and the corresponding 95% confidence interval. The post-stratified weights represent the US population. For detailed information on weight creation, please see Kapteyn et al. (2020).

[7] I would like to thank Kuma Okoro for sharing HPS public use files data and code with me. I modified the code to calculate the prevalence.

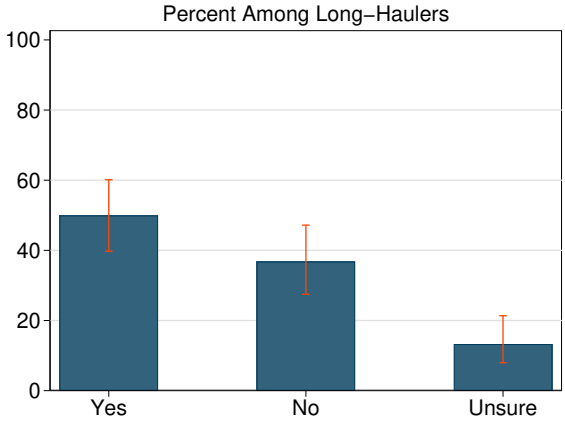
Figure 1: **Proportion of COVID and Long-Haulers**



(a) **% of who have had COVID**



(b) **% of Long-Haulers**



(c) **% of Recovered Long-Haulers**

Note: Charts used survey wave 28 respondents and used post-stratification weights. The first chart included respondents who have been tested, diagnosed, or believed to have COVID. The second chart included individuals who indicated "Yes" to the question on "Did you have COVID-related symptoms or health complications that lasted at least 12 weeks." The third chart included long-haulers who have answered "Yes" to the question of "have you recovered from your COVID-related symptoms or health complications." The second and third chart excluded affected long-haulers who had missing initial period. Please see Appendix 6.4 Table 6 for estimates. **Source**: USC UAS.

4.2 What is the Relationship between Long-Haul COVID & Labor Market Outcomes?

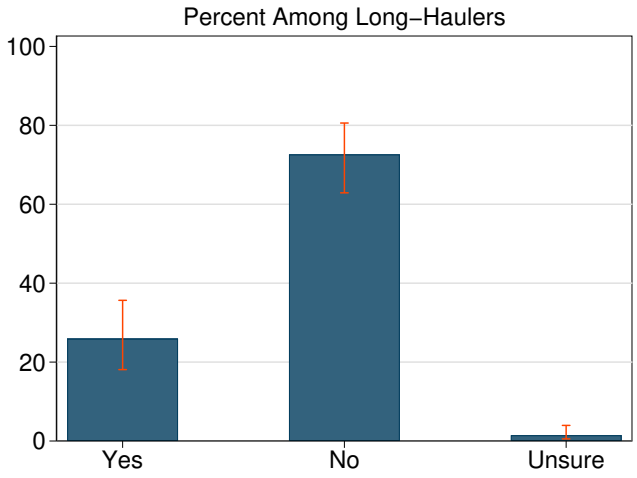
While 24.1% of individuals who have had COVID are long-haulers as of June-2021, there is a question of whether long-haul COVID affects labor market outcomes. I first discuss the proportion of long-haulers who *reported* that their health complications affected work. I then further look into the severity of long-haul COVID through different measurements. I focused on the change in employment status, employment type, "work hours in the past seven days," and "most recent paycheck" (UAS, 2020-2022). I would like to note that I used paycheck since I do not have information on wages and I do not have information on whether respondents are hourly or salaried workers. I would expect my results would align with the literature's expectation. As summarized in Currie and Madrian (1999), the literature on health and labor outcomes showed that a health shock would negatively impact an individual's labor market outcome. When applying the literature's expectations and prior evidence to the context of long-haulers, I would expect two results. Firstly, I would expect some employed long-haulers to switch labor status, such as transitioning to retirement, due to health complications negatively affecting work. Secondly, I would expect a decline in work hours or wages among long-haulers who reported their persistent health complications affect work.

4.2.1 Long-Haul COVID Affect Employment or Work Hours

Figure 2 shows that only 25.9% of long-haulers reported that long-haul COVID affected employment or work hours in mid-2021.

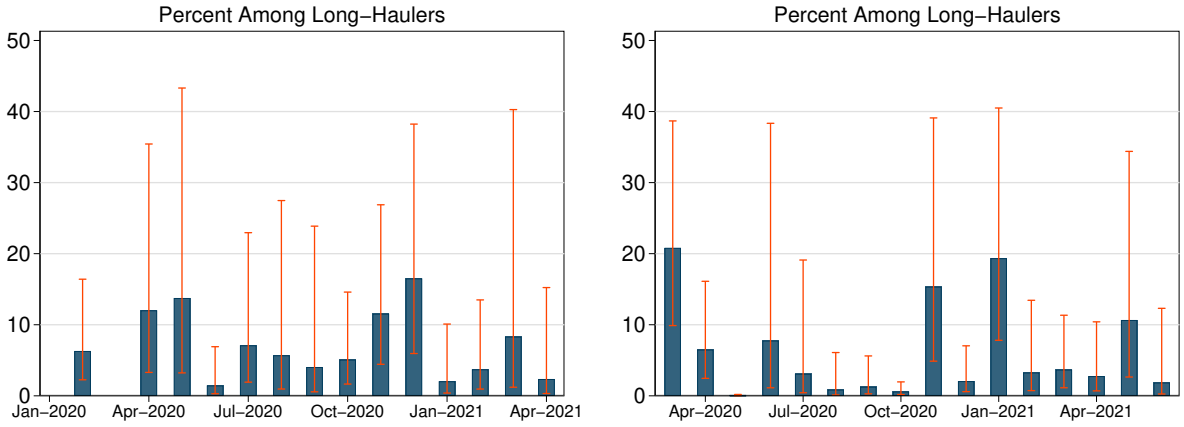
When breaking down by months, Figure 3 indicates that individuals reported having COVID mostly in the Spring of 2020 and Winter of 2020. The chart also indicates that a majority of affected long-haulers are in March-2020, November-2020, and January-2021. I would like to note that some long-haulers did not indicate having COVID in the survey despite indicating having long-haul COVID.

Figure 2: **Proportion of Long-Haulers Whose Health Complications Affected Employment or Work Hours**



Note: Chart used survey wave 28 respondents and used post-stratification weights. Chart included recoded respondents that either indicated starting to be affected prior to March-2020, or start of the survey, or after June-2021, the last month of the survey wave 28 data collection period. Chart excluded affected long-haulers who had missing base period. Please see Appendix 6.4 Table 6 for table for estimates.
Source: USC UAS.

Figure 3: **Proportion of Affected Long-Haulers by Month**

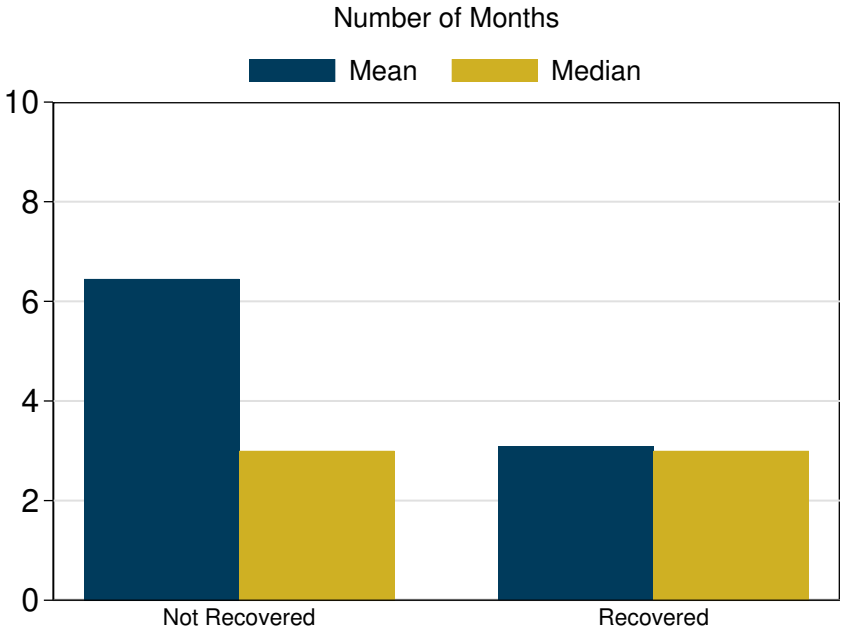


(a) **Sick** (b) **Affected**

Note: Charts used survey wave 28 respondents and used post-stratification weights. *Sick* is determined whether the respondent indicated being diagnosed, tested, or believed to have COVID. *Affected* is determined whether a respondent reported his/her COVID-related health complications affected his/her employment or work hours. Some long-haulers did not indicate having COVID in the survey despite indicating having long-haul COVID-related health complications, so the percentages will differ. Charts excluded affected long-haulers who had missing base period. Charts included recoded respondents that either indicated starting to be affected prior to March-2020, or start of the survey, or after June-2021, the last month of the survey wave's data collection period. Please see Appendix 6.4 Table 7 for estimates.
Source: USC UAS.

The duration in which long-haulers have difficulty working due to their health complications varies. Figure 4 indicates that recovered affected long-haulers have a shorter duration relative to persisting long-haulers. Among the recovered, both the mean and mean duration are about 3 months. In contrast, among those who are not recovered, the mean is about 6.5 months and the median is about three months as of June-2021.

Figure 4: **Impacted Employment and Work Hours Duration Among Affected Long-Haulers**



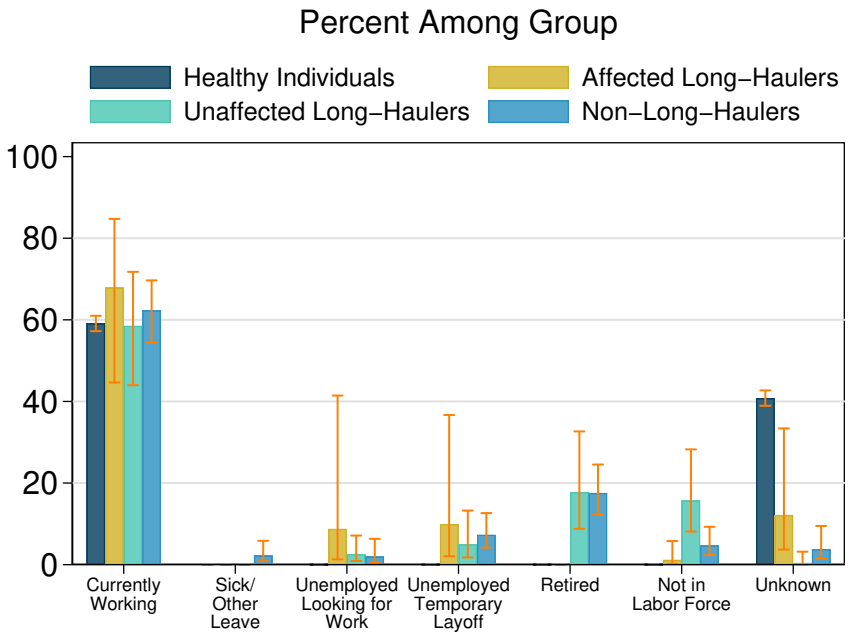
Note: Chart used survey wave 28 respondents and used post-stratification weights. Chart only included recoded *affected long-haulers* who either indicated starting to be affected prior to March-2020, or start of the survey, or after June-2021, the last month of the survey wave's data collection period. *Affected long-haulers* refer to individuals who indicated having long-haul COVID and that their complications affected work. **Source**: USC UAS.

4.2.2 Change in Employed Status and Employment Type

While I find that 25.9% of long-haulers reported their health complications affected employment or work hours, there is a question about the base period labor status. There is a possibility that these individuals have different labor statuses prior to indicating having COVID. For example, one long-hauler might be employed prior to having COVID while another long-hauler might be unemployed and looking for a job. The unemployed long-hauler might be unable to continue to look for a job due to their health complications. In

order to distinguish different cases, I looked at the *base* labor status. Figure 5 displays the reported labor status prior to the start of affected employment or work hours. 67.9% of *affected long-haulers* were reported being employed prior to having COVID. 18.7% of *affected long-haulers* were unemployed prior to having COVID while a small percentage were not in the labor force (unspecified) or unknown. When comparing against *healthy individuals*, *unaffected long-haulers* and *non-long-haulers*, a greater percentage of *affected long-haulers* reported initially working or was unemployed prior to being sick. Interestingly, I find that a majority of *healthy individuals* reported initially working or unknown and a minority of *healthy individuals* reported initially being unemployed, retired, or not in the labor force. Among *unaffected long-haulers*, I find that there is a greater proportion that reported initially retired or not in the labor force. Lastly, among *non-long-haulers*, I find that there is a greater proportion that reported initially being retired.

Figure 5: **Proportion by Base Period Labor Status**



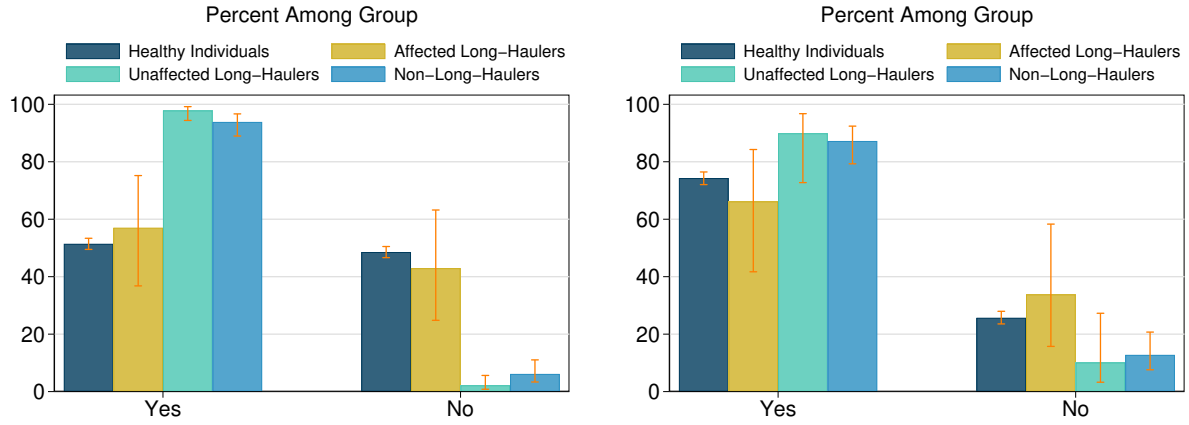
Note: Chart used survey wave 28 respondents and used post-stratification weights. Chart excluded affected long-haulers who had missing initial period or did not report labor status in all participated survey waves. *Healthy individuals* refer to individuals who have not had COVID. For *healthy individuals*, the base period labor status was the first reported labor status. *Affected long-haulers* refer to individuals who indicated having long-haul COVID and that their complications affected work. Lastly, *non-long-haulers* refer to individuals who have COVID symptoms that lasted less than 12 weeks. For *affected long-haulers* and *non-long-haulers*, the initial labor status was identified by taking the labor status in the survey wave prior to first reporting having COVID or nearest wave available. Due to scaling, *healthy individuals* who are unemployed, retired, and not in labor force are not visible. Please see Appendix 6.4 Table 8 for estimates. **Source**: USC UAS.

Given that a majority of *affected long-haulers* reported working at the initial period and the anecdotes of switching labor status, what proportion switched employment or employment type? Moreover, is this proportion of *affected long-haulers* different from other groups? As the left-hand Figure 6 shows, 57.0% of *affected long-haulers* remained employed. In contrast, only 43.0% reported otherwise. When comparing against *healthy individuals*, I find that proportion of *affected long-haulers* who remained employed is slightly higher. Among *healthy individuals*, 51.4% reported remaining employed. However, I would like to note that that the lower percentage among healthy individuals remaining in the same employment might be driven by other external factors, such as being laid-off due to the pandemic or exiting labor market to take care of children due to lack of childcare, and the calculation methodology.[8] When comparing against *unaffected long-haulers* and *non-long-haulers*, I find that proportion of *affected long-haulers* who remained employed is lower. Interestingly, 97.8% of *unaffected long-haulers* and 93.9% of *non-long-haulers* reported remaining employed. These large proportion could be driven by other external factors, such as work flexibility under different employers. This is worthy exploring in detail in future research.

However, change in employment status might not capture the change in employment type. There is a possibility that a long-hauler switched industries that provide flexible work schedules. To test this, I looked at the change in employment type, where employment type includes either being self-employed or working for an employer. Right-hand Figure 6 shows that a majority of *affected long-haulers* have remained in the same employment type even after having or undergoing long-haul COVID. 66.2% of *affected long-haulers* reported same employment type while 33.8% reported otherwise. When comparing against the three other groups, the proportion of those who remained in the same employment type among *affected long-haulers* is relatively less than the two other groups. This might support the anecdotes that some *affected long-haulers* are switching to employment types, such as gig working or individual contract work, to provide flexibility.

[8] As discussed in Section 3.4.1, I used the *first* and *last* reported labor status for *healthy individuals*. I acknowledge that this is not necessarily equivalent and comparing against other groups should be carefully considered.

Figure 6: **Change in Labor Market Outcomes**



(a) % **Remained Employed** (b) % **Remained Same Employment Type**

Note: Charts used survey wave 28 respondents and used post-stratification weights. All charts included long-haulers who have reported labor market outcomes prior to reporting having COVID and latest labor market outcome. Charts excluded *affected long-haulers* who had missing base period or did not report labor status in all participated survey waves. Employment type is defined as reported categories of either working for an employer or being self-employed. *Healthy individuals* refer to individuals who have not had COVID. *Affected long-haulers* refer to individuals who indicated having long-haul COVID and that their complications affected work. Lastly, *non-long-haulers* refer to individuals who have COVID symptoms that lasted less than 12 weeks. Please see Appendix 6.4 Table 9 for estimates. **Source**: USC UAS.

4.2.3 Change in Work Hours and Paycheck by Groups

There is a possibility that affected long-haulers might work fewer hours and thus receive a lower paycheck. To explore this, I looked at the mean change in work hours (number of hours) and recent paycheck (dollar amount in 2019 dollars) by four groups. Table 3 displayed the mean change across all four groups. For *affected long-haulers*, as expected, the mean change in hours is a decline by about 9.6 hours and mean change in paycheck amount is a decline by about $0.2. For the *healthy* group, there is an increase in mean work hours but a decline in mean paycheck. When looking at the remaining two groups, both change in mean work hours and paycheck amount declined.

Along with the decline in work hours and paycheck amount among *affected long-haulers*, I find two interesting results. Firstly, the mean change in work hours is large while the mean change in paycheck is quite small. There is a possibility that most of the respondents receive salaries rather than hourly pay, so they would less likely see a reduction in pay. Unfortunately, I do not have information on whether a respondent received a salary or hourly pay, so future studies should explore this. Secondly, the mean change in work hours and recent paycheck is large among *unaffected long-haulers*. There is a possibility that *unaffected long-haulers* are self-employed or working under employers who provide flexible working conditions. The flexibility could be seen as perk to continue working under the same employment type and therefore individuals could work less and face a decline in paycheck. Future research should explore this further.

Table 3: Estimated Means by Groups

	Mean	Std. Err.
Change in Work Hours (# of hours)		
Healthy Individuals	1.0	0.4
Affected Long-haulers	-9.6	4.4
Unaffected Long-haulers	-15.1	3.3
Non-long-haulers	-7.4	1.3
Change in Paycheck Amount ($ 2019 dollars)		
Healthy Individuals	-0.1	0.0
Affected Long-haulers	-0.2	0.1
Unaffected Long-haulers	-0.7	0.1
Non-long-haulers	-0.2	0.1

Note: Calculations only included survey wave 28 respondents and post-stratification weights. The number of work hours is the number of "work hours in the past seven days" (UAS, 2020-2022). Paycheck is "most recent paycheck" amount (in $, 2019 dollars) (UAS, 2020-2022). Some respondents were excluded since these respondents did not participate in the study once reporting having COVID or did not provide information about hours or paycheck in any survey wave. I also excluded *affected long-haulers* who had missing starting period. *Healthy individuals* refer to individuals who have not had COVID. *Affected long-haulers* refer to individuals who indicated having long-haul COVID health complications and that their complications affected their ability to work. *Unaffected long-haulers* refer to individuals who indicated having long-haul COVID complications but their complications did not affect their ability to work. Lastly, *Non-long-haulers* refer to individuals who have COVID symptoms that lasted less than 12 weeks. Please see Appendix 6.4 Table 10 for estimates rounded to two decimal places. **Source**: USC UAS, BLS.

4.3 Is Long-Haul COVID Associated with Negative Changes on Labor Market Outcomes?

There is a question whether long-haul COVID is associated with negative changes on labor market outcomes. To test this, I run four ordinary least squares (OLS) regressions on three labor market outcomes (employed status, number of work hours, and paycheck amount). For the first regression, I test on *all* long-haulers (both affected and unaffected). Then I test three regressions by splitting long-haulers into two separate groups. Lastly, I used the Wald test to test whether coefficients between *affected long-haulers* and other COVID groups (*unaffected long-haulers* and *non-long-haulers*) are different.

For the first regression, I pooled *affected* and *unaffected long-haulers* into one group called *long-haulers*. I run the following regression:

$$affected_{outcome} = \beta_0 + \beta_1 base_{outcome} + \beta_2 COVID_{non-long} + \beta_3 COVID_{long-haulers} \\ \boldsymbol{\beta x} + \epsilon$$

where $affected_{outcome}$ is the affected labor market outcome, $base_{outcome}$ is the base period labor market outcomes, $\boldsymbol{x}$ is a vector of respondent's age group, education group, race, gender, marital status, and children status as controls, $COVID_{non-long}$ is a dummy variable whether or not is a non-long-hauler, and $COVID_{long-haulers}$ is a dummy variable whether or not is a long-hauler.

For the remaining three regressions, I used the following:

$$affected_{outcome} = \beta_0 + \beta_1 base_{outcome} + \beta_2 COVID_{non-long} + \beta_{3_1} COVID_{affected-long} \\ + \beta_{3_2} COVID_{unaffected-long} + \boldsymbol{\beta x} + \epsilon$$

where I used the same controls and variables as used in the first regression. The only difference is that I split *long-haulers* into two groups where $COVID_{affected-long}$ is a dummy variable whether or not is an affected long-hauler and $COVID_{unaffected-long}$ is a dummy variable whether or not is an unaffected long-hauler. $COVID_{affected-long}$ is of particular interest.

Afterwards, I used the Wald Test to test whether there is a difference in the relationship between long-haulers (all long-haulers, affected, and unaffected) and other similar individuals. For the first regression, I tested whether there is a difference between *all* long-haulers and *non-long haulers*:

1. H_0: $\beta_2 COVID_{non-long} = \beta_3 COVID_{long-haulers}$

For the remaining three regressions, I tested whether there is a difference between affected long-haulers and other similar individuals (*non-long-haulers* and *unaffected long-haulers*):

2. H_0: $\beta_2 COVID_{non-long} = \beta_{3_1} COVID_{affected-long}$
3. H_0: $\beta_{3_2} COVID_{unaffected-long} = \beta_{3_1} COVID_{affected-long}$

4.3.1 Regressions 1 & 2: Employed

I first test whether long-haul COVID has a negative association with employed status. For the regression's dependent variable, I created a dummy variable of whether a respondent is "currently working" or otherwise ("on sick or other leave," unemployed, retired, not in the labor force, or unknown) (UAS, 2020-2022).

Table 4 Columns (1) and (2) showed regressions results. Column (1) results showed the coefficient for *long-haulers* is negative and extremely small (rounded to 0.0). This suggests that long-haulers are associated with a small negative to no percentage points of being employed relative to healthy individuals. This could be driven by unaffected long-haulers who reported that long-haul COVID health complications did not affect work. But, the coefficient is not statistically significant. Coefficient for *non-long-haulers* has the same magnitude as *long-haulers* and not statistically significant.

When breaking down by *affected* and *unaffected long-haulers*, Table 4 Column (2) shows that *affected long-haulers* coefficient is -0.1 and is statistically significant at 5% level. This suggests that *affected long-haulers* are associated with 10 percentage points less likely of being employed relative to healthy individuals. When comparing coefficient size against that of *non-long-haulers* and *unaffected long-haulers*, I find that *affected long-haulers* coefficient is larger. This significant decline is expected. Like the anecdotes about long-haulers, there is a possibility that long-haul COVID health complications make working difficult so long-haulers who reported being affected would be more likely to consider switching or continuing not work until they recover.

Now, there is a question of whether long-haulers are more impacted. As Table 5 Panel (1) indicates, I find the p-value is not statistically significant so I failed to reject that *non-long-haulers* and *long-haulers* are different. When testing whether there is a difference between (1) *non-long-haulers* and *affected long-haulers* and (2) *unaffected long-haulers* and *affected long-haulers*, Table 5 Panel (2) showed mixed results. When testing between *non-long-haulers* and *affected long-haulers*, I failed to reject the null hypothesis. In contrast, when testing between *unaffected long-haulers* and *affected long-haulers*, I reject the null hypothesis that both coefficients are not different. The difference between these two coefficients are 0.1, as displayed in the Panel (2) Row (3), suggests that *affected long-haulers* are more affected than *non-long-haulers* in terms of being employed.

4.3.2 Regression 3: Work Hours

I then test whether long-haul COVID has a negative association with work hours. For the regression's dependent variable, I took the natural log of *affected* work hours. The base paycheck is the natural log of *base* work hours.

Table 11 Column (3) showed regression results. I find that *affected long-haulers* coefficient is -0.5 and is statistically significant at 5% level. This indicates that, on average, *affected long-haulers* worked 50% less hours than *healthy individuals*. Like the employed regression, I find that coefficient for *affected long-haulers* is larger relatively to the two other groups. This aligns with my expectation since affected long-haulers reported facing difficulty to work, so they would be more likely reduce their work hours so they can accommodate their health.

When testing whether there is a difference between (1) *non-long-haulers* and *affected long-haulers* and (2) *unaffected long-haulers* and *affected long-haulers*, Table 5 Column (3) showed that there are differences between these coefficients. I reject the null hypotheses. Thus, *affected long-haulers* are more affected than *non-long-haulers* and *unaffected long-haulers* in terms of number of work hours.

4.3.3 Regression 4: Paycheck

Lastly, I test whether long-haul COVID has a negative association with paycheck. The dependent variable is the natural log of the *affected* paycheck amount. The *base* paycheck is the natural log of *base* paycheck.

Table 11 Column (4) showed regression results. I find that *affected long-haulers* coefficient is -0.1, which aligns with my expectation. I would expect long-haulers who reported their health complications are affecting work would either (1) work for less hours and thus

receive a lowered paycheck amount or (2) simply stop working for a time period and thus receive no paycheck. But this coefficient is not statistically significant. While *affected long-haulers* coefficient is larger than the two other groups, none of the coefficients are statistically significant. Hence, I failed to find evidence that there is a difference in paycheck amount for COVID groups against individuals who have not had COVID.

When testing whether there is a difference between (1) *non-long-haulers* and *affected long-haulers* and (2) *unaffected long-haulers* and *affected long-haulers*, Table 5 Panel (4) showed that I failed to reject the null hypotheses. Thus, I failed to find evidence that *affected long-haulers* are relatively affected than the other COVID groups in terms of paycheck.

Table 4: Regression Results

Variables	(1)	(2)	(3)	(4)
	Employed		**ln(Work Hours)**	**ln(Paycheck)**
	(1 = Yes, 0 = otherwise)		*(# of hours)*	*($ 2019 Dollars)*
Base				
Employed	0.7***	0.7***		
	(0.0)	(0.0)		
ln(Work Hours)			0.2***	
			(0.0)	
ln(Paycheck)				0.6***
				(0.0)
Groups				
Non-long-haulers	0.0†	0.0†	-0.2***	0.0
	(0.0)	(0.0)	(0.0)	(0.1)
Long-haulers	0.0†			
	(0.0)			
Affected Long-haulers		-0.1**	-0.5***	-0.1
		(0.1)	(0.1)	(0.2)
Unaffected Long-haulers		0.0	0.0†	0.1
		(0.0)	(0.1)	(0.2)
Controls	***Yes***	***Yes***	***Yes***	***Yes***
Constant	0.2***	0.2***	2.8***	-0.4***
	(0.0)	(0.0)	(0.1)	(0.1)
Observations	5,663	5,663	2,681	2,791
R-squared	0.6	0.6	0.1	0.5

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All regressions used post-stratification weights and only included survey wave 28 respondents. † signifies negative coefficients that were rounded to 0.0 and thus recoded to exclude negative sign. Each column is one regression with the dependent variable being the column name. Regressions 1 and 2 use the same dependent variable. Work hours are the natural log of affected number of "work hours in the past seven days" (UAS, 2020-2022). Paycheck is the natural log of affected "most recent paycheck" amount (in $, 2019 dollars) (UAS, 2020-2022). *Long-haulers* includes both *affected* and *unaffected long-haulers*. Controls included age groups, education groups, race, gender, whether have school-aged children, and marital status. Omitted group is individuals who have not had COVID (or *healthy individuals*), age group is 18 to 25 years old, education group is completing less than a high school degree, race group is White, gender is Female, school-aged children status is having at least one school-aged child, and marital group is married. For the full regression results, please see Appendix 6.4 Table 11. **Source**: USC UAS, BLS.

Table 5: Wald Test Results

	(1)	(2)	(3)	(4)
		Employed	**ln(Work Hours)**	**ln(Paycheck)**
		(1=Yes, 0 = otherwise)	*(# of hours)*	*($ 2019 dollars)*
Test 1				
H_0: $\beta_4 COVID_{unaffected-long} = \beta_3 COVID_{long-haulers}$	0.0			
Test 2				
H_0: $\beta_2 COVID_{non-long} = \beta_{3_1} COVID_{affected-long}$		0.1*	0.3**	0.1
Test 3				
H_0: $\beta_{3_2} COVID_{unaffected-long} = \beta_{3_1} COVID_{affected-long}$		0.1**	0.4***	0.2

Note: *** p<0.01, ** p<0.05, * p<0.1. Each column is one regression with the dependent variable being the column name. Regressions 1 and 2 use the same dependent variable. *Long-haulers* includes both *affected* and *unaffected long-haulers*. Each cell is the difference in coefficients from OLS regressions. All regressions only included survey wave 28 respondents and post-stratification weights. Work hours are the natural log of affected number of "work hours in the past seven days" (UAS, 2020-2022). Paycheck is the natural log of affected "most recent paycheck" amount (in $, 2019 dollars) (UAS, 2020-2022). Please see Appendix 6.4 Table 12 for estimates rounded to two decimal poins. **Source**: USC UAS, BLS.

5 Discussion and Conclusion

Using new survey data, this paper provided a glimpse on the proportion of long-haulers and the relationship between long-haulers and their labor outcomes in mid-2021. So far, less than one-fourth of individuals who have had COVID identified as long-haulers and 25.9% of long-haulers reported that their health complications affected employment or work hours. Furthermore, among affected long-haulers who were employed prior to having COVID symptoms, more than a majority have not changed employment type and continued to be employed. In addition, this paper showed that, while affected long-haulers did not change employment status as much as predicted, the mean change in "work hours in the past seven days" and "most recent paycheck" declined among affected long-haulers (UAS, 2020-2022). I then used four OLS regressions to test whether long-haul COVID is associated with negative change on selected labor market outcomes. When I combine both affected and unaffected long-haulers, I failed to find evidence that long-haulers are less likely of being employed relative to individuals who have not ha d COVID. But, when I distinguish long-haulers into affected and unaffected, I find two results. Firstly, affected long-haulers are 10 percentage points less likely to be employed relative to individuals without prior COVID infection. Secondly, affected long-haulers, on average, work 50% less hours than individuals without prior COVID infection. However, when looking at paycheck earnings, I failed to find evidence that these affected long-haulers receive a lower paycheck earning relative to individuals without prior COVID infection. When comparing affected long-haulers against unaffected long-haulers and non-long-haulers, I find evidence that affected long-haulers are more impacted in their employed status and work hours.

There are a few potential reasons for these results. The first reason is the available information on affected long-haulers. There is a possibility that long-haulers make significant labor decisions later. But, as Figure 3 depicts, survey results only captures up to June-2021. To address this, as thoroughly suggested in Bach (2022), running a much longer longitudinal survey like the UAS survey would be able to capture these labor outcomes. Another potential reason is the rise of long-hauler rehabilitation programs (Newsome, 2021). Long-haulers participating in these programs are able to receive treatment that would alleviate their health-related complications. Therefore, there is a possibility that some of long-haulers respondents are receiving treatments, so their labor market outcomes have not been as severely hit as expected. Currently, I do not have information whether the respondents have access to these programs. Hence, it might be interesting for future research and surveys to capture this information and analyze whether those who receive care are able to work

without major complications. Lastly, the measurements to capture severity, work hours and paycheck amount, might drive the results. Since the survey asks about "work hours in the past seven days" and "most recent paycheck," the results might be volatile despite taking the mean across the time period to minimize the noise (UAS, 2020-2022).

While this paper provides information about affected long-haulers, this paper has a few limitations. The first limitation is the sample size. Ideally, I would have a sufficiently large sample size to explore the prevalence among demographic characteristics. Another limitation is that I used the most conservative category of long-haul COVID. By reducing from at least 12 weeks to at least 4 weeks of having COVID related health complications, as suggested by certain medical experts, might reveal different trends.[9] In fact, given the increasingly evolving medical research on long-term COVID, my definition might become obsolete. Because of these limitations, future data collection and research would provide a more robust picture.

[9]Please see Venkatesan (2021) for more information.

6 Appendix

6.1 Definition

I used the following definitions:

- **Recovered**: a recovered affected long-hauler is a long-hauler that states yes to the variable `cvl005`.
- **Work Hours**: work hours is defined as the total number of work hours in the last seven days. The variable used is `lr008`. I replaced work hours to zero if labor status is not "currently working" or not "on sick or other leave" and missing if labor status is not reported (UAS, 2020-2022).
- **Paycheck Amount**: paycheck amount is defined as the "most recent paycheck" amount. First survey wave does not ask this question, so I used the next recent paycheck for the first survey wave if a respondent reported working in the first survey wave. I replaced "most recent paycheck" to zero if labor status is not "currently working" or not "on sick or other" leave and missing if labor status is not reported (UAS, 2020-2022).
- **Employment type**: employment type includes categories of being self-employed or working for an employer. I used `lr005` variable.

6.2 Descriptive Statistics Preparation Procedure

For descriptive statistics, I only focused on survey wave 28 participants in the longitudinal data. If a respondent did not participate in survey wave 28, then I excluded them.

- % **Remained Employed**: I used `laborstatus_covidSurv` variable and I defined employed as a respondent who reported "currently working" (UAS, 2020-2022). I calculated the percentage change in *base* period labor status and *affected* period labor status conditional on individuals who reported to work at the beginning. I identified the *base* and *affected* labor status based on three cases:
  - **Healthy Individuals**: *base* labor status is first reported labor status and *affected* labor status by taking last reported labor status. There are a few cases where the respondent who do not report labor status, so I excluded them in the calculations.

- **Affected Long-haulers**: I identified *base* labor status by taking the labor status in the survey prior to the first time the respondent reported having COVID. For respondents who did not report having COVID but indicated the specific month and year when long-haul COVID affect employment or work hours, I used the nearest wave. *Affected* labor status is the labor status in the latest survey wave of the respondent having long-haul COVID. There are a few cases where the respondent did not participate in the survey when they first reported being sick or having long-haul COVID symptoms, so this respondent was excluded in this calculation.
- **Non-long-haulers**: I used similar methodology used for *affected long-haulers*.

- % **Remained Same Employment Type**: using the `lr005` variable, I used a similar method as applied when calculating *% remain employed*. Since the employment type was not asked in the first UAS survey wave, I used the next reported employment type for the first survey wave if a respondent reported working in the first survey wave.

- **Duration of Having Long-Haul COVID Impacting Employment or Work Hours**: I only focused on *affected long-haulers*. Since I do not have the exact date, I assumed that the duration occurs throughout the *entire* month. I defined the start of having COVID when respondent indicated the specific month and year through the variables `cvl004_month` and `cvl004_year`. I defined the end of duration of having COVID if the respondent indicated recovering from COVID using the variables `cvl006_month` and `cvl006_year`. If a respondent did not indicate recovering from COVID, then I substituted the end of the duration with June-2021.

- **Mean Change in Work Hours**: using `lr008`, I identified the *base* period and *affected* period work hours. Then I calculated the difference for each respondent and then took the mean by group. *Base* and *affected* work hours were identified by four groups:

  - **Healthy Individuals**: *base* work hours is the mean amount in the first participated survey wave. *Affected* work hours is the last reported work hours.
  - **Affected Long-haulers & Unaffected Long-haulers**: *base* work hours is the mean amount across survey waves prior to the survey wave that the respondent first indicating having COVID from a test, diagnosis, or belief. *Affected* work hours is the mean work hours during the period of reported having long-haul COVID.

  - **Non-long-haulers**: *base* work hours is the mean amount in survey waves prior to the survey wave that the respondent first indicating having COVID from a test, diagnosis, or belief. *Affected* work hours as the mean work hours across all survey waves who reported having COVID.

- **Mean Change in Paycheck**: I used the variable `lr011`, which provides the most recent paycheck amount. Using Federal Reserve Bank of St. Louis FRED's *US Bureau of Labor Statistics Consumer Price Index (CPI) for All Urban Consumers: All Items in US City Average*, I converted the paycheck amount to 2019 real dollars (U.S. Bureau of Labor Statistics, 2020-2021). I identified the *base* period and *affected* period paycheck among all respondents in my subset. Then I calculated the difference for each respondent and then took the mean by groups using the same methodology used to calculate *change in work hours*.

6.3 Regressions Preparation Procedure

To test whether long-haul COVID has a negative association on labor market outcomes, I calculated three groups of variables that I used in all regressions.

- **Base Outcomes**

  1. **Employed**: to identify the *base* period labor status by group, I used the same methodology when identifying *change in employment*. Then I coded whether the *base* employment is "currently working" or otherwise ("on sick or other leave," unemployed, retired, not in the labor force, or unknown) (UAS, 2020-2022).
  2. **Work Hours or Paycheck**: I identified *base* period mean work hours and paycheck by group by using the same methodology when identifying *mean change in work hours or paycheck* except for calculating the mean by group. Instead, I took the natural log of *base* work hours and paycheck for each respondent.

- **Affected Outcomes**

  1. **Employed**: I identified the *affected* labor status by group by using the same methodology when identifying *change in employment*. Then I coded whether the *affected* employment is "currently working" or otherwise ("on sick or other leave," unemployed, retired, not in the labor force, or unknown) (UAS, 2020-2022).

2. **Natural Log of Work Hours and Paycheck**: I identified the *affected* mean work hours and paycheck by group by using similar methodology when identifying the *mean change in work hours or paycheck* except for calculating the mean by group. Instead, I took the natural log of *base* work hours and paycheck for each respondent.

- **Controls - Demographic Characteristics**: to control for respondent's characteristics, I used the following imputed demographic characteristics

1. **Age Groups**: I used the `age` variable to create age groups. The age groups included 18 to 25, 25 to 29, 30 to 34, 35 to 44, 45 to 54, 55 to 64, 65 to 74, and 75 years and older. All respondents are at least 18 years old.
2. **Education Groups**: I used the `education` variable to create education groups. Education groups are completed less than high school, high school, some college, college, and post-college, such as graduate school.
3. **Marital Status**: I used the `maritalstatus` variable to create a dummy variable where I indicated whether or not the respondent was married.
4. **School-Aged Children Status**: I used the `totalk12` variable, which provides information on "the number of children in elementary, middle or high school" (UAS, 2020-2022). I created a dummy variable where I indicated whether or not a respondent has at least one school-aged child.
5. **Race**: I used the `race` variable where race groups included White, Black, American Indian and Alaska Native, Asian, Hawaiian and Pacific Islander, and Mixed (UAS, 2020-2022).
6. **Gender**: I used the `gender` variable that reported a respondent as a male or female.

6.4 Descriptive Statistics & Regression Tables

This section contains tables with proportion and 95% confidence intervals for figures 1, 2, 3, 5, and 6. Moreover, this section contains Table 10 and Table 12 that are rounded to two decimal points. Lastly, this section contains the full results for all four regressions from Table 4.

Table 6: Proportion of COVID and Long-Haul COVID

Question		Denominator Description	Proportion (%)	95% CI (%)
Ever Had COVID	Yes	All Population	13.43	[12.24, 14.73]
	No		81.33	[79.85, 82.71]
	Unsure		5.24	[4.47, 6.13]
Ever Had Long-Haul COVID	Yes	Among COVID Population	24.11	[20.08, 28.66]
	No		70.89	[66.14, 75.23]
	Unsure		5.00	[3.21, 7.70]
Ever Had COVID-related Complications Affected Employment or Work Hours	Yes	Among Long-Haulers	25.92	[18.09, 35.65]
	No		72.62	[62.89, 80.58]
	Unsure		1.47	[0.53, 3.96]
Ever Recovered from COVID-related Health Complications	Yes		49.94	[39.76, 60.13]
	No		36.78	[27.46, 47.19]
	Unsure		13.28	[7.95, 21.36]

Note: Questions were fielded in UAS 346 Wave 28 from May 12, 2021 to June 22, 2021. Calculations only included survey wave 28 respondents and used post-stratification weights. Table excluded affected long-haulers who had missing starting period. **Source**: USC UAS.

Table 7: Proportion of Long-Haulers Indicating Health Affected Employment or Work Hours by Starting Month

Date	**Proportion (%)**	**95% CI (%)**
Mar-2020	20.82	[9.88, 38.68]
Apr-2020	6.51	[2.46, 16.11]
May-2020	0.03	[0.00, 0.19]
Jun-2020	7.77	[1.13, 38.34]
Jul-2020	3.10	[0.43, 19.11]
Aug-2020	0.87	[0.12, 6.09]
Sep-2020	1.27	[0.28, 5.61]
Oct-2020	0.60	[0.18, 1.96]
Nov-2020	15.36	[4.88, 39.10]
Dec-2020	2.06	[0.58, 7.04]
Jan-2021	19.36	[7.81, 40.50]
Feb-2021	3.28	[0.73, 13.44]
Mar-2021	3.68	[1.13, 11.34]
Apr-2021	2.77	[0.69, 10.41]
May-2021	10.66	[2.65, 34.39]
Jun-2021	1.86	[0.26, 12.31]

Note: Questions were fielded in UAS 346 Wave 28 from May 12, 2021 to June 22, 2021. Calculations only included survey wave 28 long-haulers and used post-stratification weights. A few respondents were excluded since they did not provide starting date. Calculations included recoded respondents that either indicated starting to be affected prior to March-2020, or start of the survey, or after June-2021, the last month of the survey wave's data collection period. For recoding details, please see Section 3. **Source**: USC UAS.

Table 8: Proportion by Base Period Labor Status

Group	Labor Status	Proportion (%)	95% CI (%)
Healthy Individuals	Currently Working	59.12	[57.22, 61.00]
	Sick or Other Leave*	-	-
	Unemployed - Looking for Work	0.01	[0.00, 0.06]
	Unemployed - Temporary Layoff	0.03	[0.01, 0.07]
	Retired	0.02	[0.01, 0.05]
	Not in Labor Force	0.02	[0.01, 0.07]
	Unknown	40.80	[38.92, 42.70]
Affected Long-haulers	Currently Working	67.90	[44.65, 84.72]
	Sick or Other Leave*	-	-
	Unemployed - Looking for Work	8.79	[1.29, 41.44]
	Unemployed - Temporary Layoff	9.93	[2.05, 36.67]
	Retired*	-	-
	Not in Labor Force	1.20	[0.24, 5.78]
	Unknown	12.19	[3.70, 33.40]
Unaffected Long-haulers	Currently Working	58.55	[43.98, 71.76]
	Sick or Other Leave*	-	-
	Unemployed - Looking for Work	2.56	[0.89, 7.13]
	Unemployed - Temporary Layoff	4.97	[1.76, 13.25]
	Retired	17.76	[8.78, 32.65]
	Not in Labor Force	15.71	[8.11, 28.25]
	Unknown	0.45	[0.06, 3.18]
Non-long-haulers	Currently Working	62.34	[54.40, 69.66]
	Sick or Other Leave	2.25	[0.85, 5.85]
	Unemployed - Looking for Work	1.99	[0.61, 6.32]
	Unemployed - Temporary Layoff	7.34	[4.16, 12.63]
	Retired	17.58	[12.27, 24.54]
	Not in Labor Force	4.71	[2.34, 9.27]
	Unknown	3.79	[1.46, 9.47]

Note: * indicates no respondents reported that particular base period labor status. Questions were fielded in UAS 346 Wave 28 from May 12, 2021 to June 22, 2021. Calculations only included survey wave 28 respondents and used post-stratification weights. Table excluded respondents who had missing base period or did not report labor status in all participated survey waves. **Source**: USC UAS.

Table 9: Change in Labor Market Outcomes

Group	Question		Denominator	Proportion (%)	95% CI (%)
Healthy Individuals	Employment Status	Yes	Employed Prior to Reporting Having COVID within group	51.44	[49.50, 53.37]
		No		48.56	[46.63, 50.50]
Affected Long-haulers		Yes		57.05	[36.80, 75.19]
		No		42.95	[24.81, 63.20]
Unaffected Long-haulers		Yes		97.83	[94.38, 99.18]
		No		2.17	[0.82, 5.62]
Non-long-haulers		Yes		93.86	[88.96, 96.66]
		No		6.14	[3.34, 11.04]
Healthy Individuals	Employment Type	Yes	Employed Population	74.31	[72.05, 76.45]
		No		25.69	[23.55, 27.95]
Affected Long-haulers		Yes		66.19	[41.70, 84.27]
		No		33.81	[15.73, 58.30]
Unaffected Long-haulers		Yes		89.89	[72.74, 96.74]
		No		10.11	[3.26, 27.26]
Non-long-haulers		Yes		87.22	[79.29, 92.4]
		No		12.78	[7.60, 20.71]

Note: Questions were fielded in UAS 346 Wave 28 from May 12, 2021 to June 22, 2021. Table includes those who have had COVID or long-haul COVID. Calculations only included survey wave 28 respondents and used post-stratification weights. Table excluded affected long-haulers who had missing starting period or did not report labor status in all participated survey waves. **Source**: USC UAS.

Table 10: Estimated Means by Groups

	Mean	Std. Err.
Change in Work Hours (# of hours)		
Healthy Individuals	0.98	0.37
Affected Long-haulers	-9.58	4.40
Unaffected Long-haulers	-15.05	3.33
Non-long-haulers	-7.35	1.31
Change in Paycheck Amount ($ 2019 dollars)		
Healthy Individuals	-0.05	0.05
Affected Long-haulers	-0.24	0.12
Unaffected Long-haulers	-0.66	0.14
Non-long-haulers	-0.20	0.07

Note: Calculations only included survey wave 28 respondents and post-stratification weights. The number of work hours is the number of "work hours in the past seven days" (UAS, 2020-2022). Paycheck is "most recent paycheck" amount (in $, 2019 dollars) and converted 2019 dollars (UAS, 2020-2022). Some respondents were excluded since these respondents did not participate in the study once reporting having COVID or did not provide information about hours or paycheck in any survey wave. I also excluded *affected long-haulers* who had missing starting period. *Healthy individuals* refer to individuals who have not had COVID. *Affected long-haulers* refer to individuals who indicated having long-haul COVID health complications and that their complications affected their ability to work. *Unaffected long-haulers* refer to individuals who indicated having long-haul COVID complications but their complications did not affect their ability to work. Lastly, *Non-long-haulers* refer to individuals who have COVID symptoms that lasted less than 12 weeks. **Source**: USC UAS, BLS.

Table 11: Regression Results

Variables	(1) **Employed** *(1 = Yes, 0 = otherwise)*	(2) **Employed** *(1 = Yes, 0 = otherwise)*	(3) **ln(Work Hours)** *(# of hours)*	(4) **ln(Paycheck)** *(2019 Dollars)*
Base				
Employed	0.69***	0.69***		
	(0.01)	(0.01)		
ln(Work Hours)			0.23***	
			(0.01)	
ln(Paycheck)				0.56***
				(0.02)
Groups				
Non-long-haulers	-0.01	-0.01	-0.20***	0.03
	(0.02)	(0.02)	(0.04)	(0.06)
Long-haulers	-0.01			
	(0.03)			
Affected Long-haulers		-0.10**	-0.46***	-0.09
		(0.05)	(0.11)	(0.19)
Unaffected Long-haulers		0.02	-0.01	0.08
		(0.03)	(0.12)	(0.20)
Demographics				
Age Group				
25-29 years old	-0.09***	-0.09***	-0.03	0.17
	(0.02)	(0.02)	(0.06)	(0.10)
30-34 years old	-0.07***	-0.07***	0.05	0.23**
	(0.02)	(0.02)	(0.06)	(0.10)
35-44 years old	-0.05**	-0.06**	-0.01	0.22**
	(0.02)	(0.02)	(0.05)	(0.09)
45-54 years old	-0.09***	-0.09***	-0.00†	0.13
	(0.02)	(0.02)	(0.05)	(0.09)
55-64 years old	-0.12***	-0.12***	-0.06	0.19**
	(0.02)	(0.02)	(0.05)	(0.09)
65-74 years old	-0.28***	-0.28***	-0.21***	0.21*
	(0.02)	(0.02)	(0.07)	(0.11)
75+ years old	-0.27***	-0.27***	-0.29***	-0.08
	(0.03)	(0.03)	(0.11)	(0.18)
Education Group				
High School	0.02	0.02	-0.09*	0.06
	(0.02)	(0.02)	(0.05)	(0.09)
Some College	0.03*	0.03*	-0.10*	0.14
	(0.02)	(0.02)	(0.05)	(0.09)
College	0.06***	0.07***	-0.08	0.40***
	(0.02)	(0.02)	(0.05)	(0.09)
Post-college	0.08***	0.08***	-0.09*	0.61***
	(0.02)	(0.02)	(0.05)	(0.09)
Race				
Black	-0.03***	-0.03***	-0.05*	-0.05
	(0.01)	(0.01)	(0.03)	(0.05)
American Indian/Alaska Native	-0.06	-0.06	0.17	0.42**
	(0.05)	(0.05)	(0.12)	(0.20)
Asian	0.02	0.02	0.04	0.08
	(0.02)	(0.02)	(0.04)	(0.07)
Hawaiian/Pacific Islander	-0.03	-0.03	-0.11	-0.18
	(0.08)	(0.08)	(0.19)	(0.33)
Mixed	-0.02	-0.02	-0.05	-0.04
	(0.02)	(0.02)	(0.05)	(0.08)
Gender				
Male	0.04***	0.04***	0.09***	0.09***
	(0.01)	(0.01)	(0.02)	(0.03)
Have School-aged Children				
None	0.01	0.01	0.07***	-0.00†
	(0.01)	(0.01)	(0.02)	(0.04)
Marital				
Not married	-0.03***	-0.04***	0.05**	-0.00†
	(0.01)	(0.01)	(0.02)	(0.04)
Constant	0.23***	0.23***	2.82***	-0.44***
	(0.03)	(0.03)	(0.09)	(0.12)
Observations	5,663	5,663	2,681	2,791
R-squared	0.62	0.62	0.13	0.45

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All regressions used post-stratification weights and only included survey wave 28 respondents. † signifies negative coefficients that were rounded to 0.0 and thus recoded to exclude negative sign. Each column is one regression with the dependent variable being the column name. Regressions 1 and 2 use the same dependent variable. Work hours are the natural log of affected number of "work hours in the past seven days" (UAS, 2020-2022). Paycheck is the natural log of affected "most recent paycheck" amount (in $, 2019 dollars) (UAS, 2020-2022). *Long-haulers* includes both *affected* and *unaffected long-haulers*. Controls included age groups, education groups, race, gender, whether have school-aged children, and marital status. Omitted group is individuals who have not had COVID (or *healthy individuals*), age group is 18 to 25 years old, education group is completing less than a high school degree, race group is White, gender is Female, school-aged children status is having at least one school-aged child, and marital group is married. **Source**: USC UAS, BLS.

Table 12: Wald Test Results

	(1)	(2)	(3)	(4)
	Employed		**ln(Work Hours)**	**ln(Paycheck)**
	(1=Yes, 0 = otherwise)		*(# of hours)*	*($ 2019 dollars)*
Test 1				
H_0: $\beta_4 COVID_{unaffected-long} = \beta_3 COVID_{long-haulers}$	0.00			
Test 2				
H_0: $\beta_2 COVID_{non-long} = \beta_{3_1} COVID_{affected-long}$		0.09*	0.26**	0.11
Test 3				
H_0: $\beta_{3_2} COVID_{unaffected-long} = \beta_{3_1} COVID_{affected-long}$		0.12**	0.45***	0.16

Note: *** p<0.01, ** p<0.05, * p<0.1. Each column is one regression with the dependent variable being the column name. Regressions 1 and 2 use the same dependent variable. *Long-haulers* includes both *affected* and *unaffected long-haulers*. Each cell is the difference in coefficients from OLS regressions. All regressions only included survey wave 28 respondents and post-stratification weights. Work hours are the natural log of affected number of "work hours in the past seven days" (UAS, 2020-2022). Paycheck is the natural log of affected "most recent paycheck" amount (in $, 2019 dollars) (UAS, 2020-2022). **Source**: USC UAS, BLS.

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