CENTER *for* RETIREMENT RESEARCH *at* BOSTON COLLEGE

HOW MIGHT COVID-19 AFFECT FUTURE EMPLOYMENT, EARNINGS, AND OASI CLAIMING?

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Abstract

The medium- and long-term effects of the COVID-19 pandemic are of continued interest to policymakers, advocates, and academics. Given the importance of health in decisions to work, earn, and eventually claim OASI benefits, COVID may have long-term effects on programs SSA administers even well after the official end of the pandemic. To this end, this report examines how COVID has affected the health of Americans, as well as their employment, earnings, and OASI claiming since the onset of the pandemic. The focus is on two main channels. First, the pandemic led to disruptions in the supply of healthcare that may have delayed or prevented required care. Second, infection may have led to an array of post-acute and chronic conditions, so-called long COVID.

To examine these channels, the analysis focuses on mid- to late-career individuals, defined as those who were between the ages of 50 and 75 when the pandemic began in 2020. It uses rich longitudinal data on health and employment before, during, and after the pandemic from the *Health and Retirement Study* (HRS), a nationally representative survey of individuals 50 and older, interviewed every two years until death. The HRS is the preeminent data source for addressing how health and employment evolve over time.

There are a number of principal findings:

- Almost one-third of individuals in this age group experienced a disruption in their healthcare during the pandemic, with the highest incidence among female, more educated, and single individuals, as well as those with pre-pandemic heart and lung diseases, arthritis, and psychiatric and depressive conditions.
- After accounting for a wide array of demographic factors, pre-pandemic health, insurance coverage, and pre-pandemic employment status, there is little association between having experienced a healthcare disruption and the likelihood of being employed late in the pandemic.
- Disruptions in the normal supply of healthcare, which were at the time largely out of the control of individuals, are likely not an important concern for the evolution of employment in the post-pandemic labor market.
- Sixteen percent of American adults between the ages of 50 and 75 ever had long COVID as of July 2024, with 5 percent currently suffering from the condition.

- After accounting for a wide array of demographic factors, pre-pandemic health, insurance coverage, and pre-pandemic employment status, female and more educated individuals were more likely to have had long COVID, with Blacks less likely. Those with pre-pandemic heart and lung disease, arthritis, and depressive conditions were more likely as well.
- Individuals suffering from long COVID were 9 percentage points less likely to be employed late in the pandemic. Roughly half of 50 to 75 year olds were employed in 2018, prior to the pandemic. Therefore, the 9 percentage-point reduction in employment from long COVID is a substantive economic reduction in work.
- As of 2023, there has been little statistically discernable effect of long COVID on OASDI claiming behavior.

Introduction

The medium- and long-term effects of the COVID-19 pandemic are of continued interest to policymakers, advocates, and academics. Given the importance of health in decisions to work, earn, and eventually claim OASI benefits, COVID may have long-term effects on programs SSA administers even well after the official end of the pandemic. To this end, this report examines how COVID has affected the health of Americans, as well as their employment, earnings, and OASI claiming since the onset of the pandemic.

The focus is on two main channels. First, the pandemic led to disruptions in the supply of healthcare that may have delayed or prevented required care. Second, infection may have led to an array of post-acute and chronic conditions, so-called long COVID. Specifically, long COVID is characterized by one or more symptoms that persist roughly three months or more after acute infection. These commonly can be fatigue, muscle weakness, and trouble breathing, but may also present in a variety of organ systems. It may prevent or otherwise limit an individual from returning to work or other daily activities.

To examine these channels, the analysis focuses on mid- to late-career individuals, defined as those who were between the ages of 50 and 75 when the pandemic began in 2020. It uses cross-sectional data from the *Health and Retirement Study* (HRS), a nationally representative survey of individuals 50 and older, interviewed every two years until death. The HRS is the preeminent data source for measuring how health and employment evolve over time.

The report begins with a descriptive analysis of both channels. Based on the HRS, almost one-third of individuals in this age group experienced a disruption in their healthcare during the pandemic, with the highest incidence among female, more educated, and single individuals, as well as those with pre-pandemic heart and lung disease, arthritis, and psychiatric and depressive conditions. After accounting for a wide array of demographic factors, pre-pandemic health, insurance coverage, and pre-pandemic employment status, there is little association between having experienced a healthcare disruption and the likelihood of being employed late in the pandemic, defined as the 2022-2023 period. Similarly, there was little impact on annual earnings from disruptions. Therefore, disruptions in the normal supply of healthcare, which were at the time largely out of the control of individuals, are likely not an important concern for the evolution of employment in the post-pandemic labor market.

Based on the U.S. Census Bureau's *Household Pulse Survey,* 16 percent of American adults between the ages of 50 and 75 ever had long COVID as of June 2024, with 5 percent currently suffering from the condition. The HRS yields similar numbers and indicates that after accounting for a wide array of demographic factors, pre-pandemic health, insurance coverage, and pre-pandemic employment status, female and more educated individuals were more likely to have had long COVID, with Blacks less likely. Those with pre-pandemic heart and lung disease, arthritis, and depressive conditions were more likely as well.

The empirical analysis then pivots to the estimation of the causal impact of long COVID on employment. The fundamental challenge here is those who experienced long COVID were not randomly assigned across adults. Indeed, long COVID symptoms are very heterogeneous. Individuals who developed it may have been systematically different from those who did not, in ways also related to their propensity for work. The key innovation in the analysis is the development of an instrumental variable estimation strategy based on an individual's pre-pandemic systemic (i.e., chronic low-grade) inflammation to identify the causal impact of long COVID on employment using HRS data.

Specifically, the first stage models the likelihood of long COVID status as a function of pre-existing health conditions, including the extent to which the immune system was latently dysregulated prior to the arrival of the novel coronavirus. The central mechanism is that infection of a person so primed increases the likelihood of post-acute symptoms in a way that is unrelated to what otherwise would have been the individual's labor force attachment in the absence of the pandemic. Inflammation is measured by the level of C-Reactive Protein (CRP) gathered from blood samples taken by the HRS in 2016, prior to the pandemic. CRP is a standard clinical measure of inflammation. There is a lengthy medical literature linking chronic inflammation and immune dysregulation to the likelihood of developing post-acute COVID symptoms. The first-stage maximum likelihood estimates indicate a strong relationship between pre-pandemic inflammation and the likelihood of long COVID: after controlling for differences in demographics, circulating variant transmissibility, region, pandemic stage, and pre-pandemic medical and behavioral risk factors: a doubling of pre-pandemic CRP increases the probability of experiencing long COVID by 10 percent.

The second stage then estimates the causal impact of long COVID on the likelihood the individual was employed in the 2022-2023 period measured by the 2022 HRS wave, using the probability of long COVID based on pre-pandemic latent chronic inflammation calculated in the first stage. The resulting maximum likelihood probit estimates indicate that experiencing long COVID reduces the likelihood of post-pandemic employment by 9 percentage points. Roughly half of 50 to 75 year olds were employed in 2018, prior to the pandemic. Therefore, the 9 percentage point reduction in employment from long COVID is a substantive economic reduction in work for the affected individuals. This translates into a reduction annual earnings by 10 percent. Most of the reduction in employment comes from a decline in full-time work.

To the extent to these employment effects are persistent, long COVID may end up a gateway to accelerated labor force exit and OASDI claiming. Using a similar econometric strategy, long COVID raises the likelihood of reporting being fully retired by 17 percentage points, an economically large and statistically significant effect. However, some of this effect is offset by a reduction in the likelihood of identifying as partially retired (of 3 percentage points). There is little discernable evidence that these changes to employment and self-identified retirement status have manifested themselves in claiming behavior for OASDI benefits.

Understanding health effects from COVID and how that may affect ability to work, especially at older ages, is central to understanding the near- and longer-term trajectory of SSA programs and the populations they serve. This research includes a nascent but expanding literature on medical utilization, morbidity, and mortality (Alsan, Chandra, and Simon 2021; Cronin and Evans 2021; Mulligan and Arnott 2022; Ziedan, Simon, and Wing 2022; among others) and impacts on employment and retirement (Chen, Munnell, and Liu 2022; Coile and Zhang 2022; Couch, Fairlie, and Xu 2020; Davis et al. 2023; Goda et al. 2022; among others), and an advancing medical literature on the impact of long COVID (Omarjee et al. 2020; Perlis et al. 2023; Griffin et al. 2024; Zhang et al. 2024, among others). These findings will be of use to other researchers, SSA, and may suggest promising directions for new research as policy options are analyzed to address the near- and longer-term fallout from the pandemic.

The report is organized as follows. Section 2 describes the HRS data, construction of the analysis samples, presents descriptive statistics on the prevalence of healthcare disruptions and long COVID, and identifies differences by race, ethnicity, sex, education, marital status, age, and pre-pandemic health status. Section 3 presents estimates of the relationship between healthcare disruptions and employment and earnings. Section 4 lays out the instrumental variable identification strategy and presents estimates of the causal impact of long COVID on employment, earnings, and OASI claiming. The second estimates the impact of these changes in health on employment, earnings, OASDI claiming. The final section presents a discussion of the policy implications of the findings and discusses caveats.

Data and Descriptive Statistics

The central data source is the HRS, which gathered longitudinal data on health, employment, earnings, and claiming before, during, and after the pandemic. Specifically, the 2020 wave asked questions about whether the individual had had COVID, experienced any long COVID symptoms, and any pandemic-related delays or disruptions in health care. The 2022 wave asked a similar set of questions. The measurement of long COVID is based on the following questions:

> "Did you ever have symptoms? (People with COVID-19 may experience fever chills, a cough, shortness of breath or difficulty breathing, fatigue, body aches, headache, new loss of taste or smell, sore throat, congestions or runny nose, nausea/vomiting, diarrhea.)"

followed up by:

> "Do you continue to have health problems related to your experience with COVID-19?"

In 2020, disruptions in care were asked:

> "Since March 2020, was there any time when you needed medical or dental care, but delayed getting it, or did not get it at all?"

and in 2022, since the last interview or in the last two years:

> "Was there any time when you needed medical care, but did not get it?"

The interviews for the 2020 wave were conducted between March 2020, and May 2021, so the beginning stages of the pandemic. The interviews for the 2022 wave were conducted between March 2022 and September 2023, so the late stages of the pandemic. In addition, the HRS fielded an off-year survey – the *Perspectives on the Pandemic* supplement – in two phases (to a subset of the respondents) in the Spring and Fall 2021, respectively. This supplement measured COVID, long COVID, and healthcare disruptions as well. Taken together, these three sources provide two to three snapshots of respondents during various stages of the pandemic.

The sample consists of late-career individuals, defined as those who were 50-75 years old in 2020, resided within the United States when the pandemic commenced, and completed both the 2018 (pre-) and 2022 (late-pandemic) waves. There were a total of 8,351 individuals who met these criteria.

Column 1 of Panel A of Table 1 shows sample means for selected demographic variables (and standard deviations for continuous measures). The sample is majority female, with 60 percent identifying as White, 25 percent Black, with the remaining 15 percent as other races. Just over 18 percent identify as Hispanic. Panel B shows the means for pre-pandemic medical conditions and behavioral risk factors as measured in the 2018 wave. As is typical for this age range, these individuals have many comorbidities. More than half reported suffering from arthritis and high blood pressure, and almost 44 percent were clinically obese based on body mass index (BMI).

Columns 2 and 3 split the sample into subsamples by whether the individual had ever experienced a delay in health care since the beginning of the pandemic. Almost one-third of respondents reported having had such a delay. Column 4 shows the difference in sub-sample means for each characteristic, with asterisks indicating statistically significant differences (*** less than or equal to 1 percent significance; ** 1-5 percent significance; * 5-10 percent significance). Having experienced a delay was not balanced across demographic groups. Women, Whites, and college graduates were more likely to have experienced a disruption in care; Hispanics, those with a high school degree and married were less likely. Having experienced a delay also was not balanced across pre-existing health status. Those with heart and lung disease, arthritis, psychiatric conditions, and depression were more likely to have experienced a disruption in care. There was no difference by health insurance status.

Columns 5 and 6 split the sample into subsamples by whether the individual ever had long COVID since the beginning of the pandemic. Just over 8 percent reported having had long COVID. Column 7 shows the difference in sub-sample means by long COVID status. Having experienced long COVID was not balanced across demographic groups. Women, Whites, Hispanics, and those with some college were more likely to have had long COVID; Blacks and college graduates were less likely. Long COVID also was not balanced across pre-existing health status. Those with heart and lung disease, arthritis, psychiatric conditions, depression, and were clinically obese were more likely to have had long COVID.

As many of the characteristics in Table 1 share variation with each other, Table 2 moves to a regression-based framework. In particular, column 1 shows the marginal effects from probit maximum likelihood estimation in which the dependent variable is whether the individual experienced a pandemic-related disruption in healthcare as a function of the demographic and health characteristics in Table 1, along with controls for region of residence and calendar time. Standard errors for the marginal effects are shown in parentheses, with asterisks indicating statistical significance (*** less than or equal to 1 percent significance; ** 1-5 percent significance; * 5-10 percent significance). Controlling for all these factors simultaneously, female, more educated, and single individuals were more likely to have experienced a disruption, as well as those with pre-pandemic heart and lung disease, arthritis, and psychiatric and depressive conditions. Once other factors are accounted for, there are few discernible differences in disruption by race and ethnicity.

Similarly, Column 2 shows the marginal effects when the dependent variable is whether the individual experienced long COVID. Controlling for all other factors, female and more educated individuals were more likely to have had long COVID, with Blacks less likely. Those with pre-pandemic heart and lung disease, arthritis, and depressive conditions were more likely as well. Overall, these results highlight the roles of sex, education, and pre-pandemic health status as important correlates with potential health-related effects of the pandemic.

Healthcare Disruptions and Employment

To determine the impact of healthcare disruptions on employment, the following econometric framework was used:

$$Y_{it} = \alpha + \delta D_{it}^{Ever\ COVID} + \beta D_{it}^{Long\ COVID} + \gamma D_{it}^{Disrupted} + \theta \boldsymbol{X}_{it-1} + u_{it}, \qquad (1)$$

where i and t index individuals and time period, respectively. Y is an indicator for employment (1 if employed in period t, and 0 otherwise). Here, t refers to the 2022 wave of the HRS, so that the dependent variable is late-pandemic employment, which technically was in the 2022-2023 range. Likewise, t - 1 refers to the 2018 wave, which is pre-pandemic. The focal explanatory variable is $D^{Disrupted}$, an indicator for whether the individual reported having delayed care or was denied care in the pandemic. The associated parameter, γ, measures the impact of healthcare disruptions during the pandemic on late-pandemic employment; if disruptions lead to worse health and capacity to work, then $\gamma<0$. $D^{Ever\ COVID}$ is an indicator for whether the individual reported ever having had COVID: 1 if so, 0 otherwise. Likewise, $D^{Long\ COVID}$ is an indicator for whether the individual reported suffering from long COVID. $\boldsymbol{X}$ is a rich vector of pre-pandemic control variables to account for other potentially confounding influences.

Column 1 of Table 3 shows the baseline probit estimate of γ with no controls other than $D^{Ever\ COVID}$ and $D^{Long\ COVID}$. Column 2 adds in the controls from Table 2 (demographics, region, calendar time, pre-pandemic medical conditions, behavioral risk factors, and health insurance coverage). Column 3 adds in a control for pre-pandemic employment status (measured in the 2018 wave). Across the three specifications, there is little relationship between healthcare disruptions during the pandemic and late-pandemic employment. The point estimates of γ are very close to zero and, given the associated standard errors, not statistically different than zero at conventional significance levels.

Long COVID and Employment

Long COVID is characterized by one or more symptoms persisting three or more months after acute infection. These symptoms commonly include fatigue, muscle weakness, and trouble breathing, but may also affect a variety of organ systems. According to the July 2024 Census *Household Pulse Survey,* 15 million Americans ages 50-75 reported ever having had long COVID, and 5 million reported currently experiencing it. The Social Security Administration recently commissioned a National Academies report to gauge the impact of long COVID on functional status and capacity for work. Given the share of adults affected, the extent to which long COVID affects health has potentially important consequences for labor-market attachment and social insurance programs.

Simple correlational estimates from Census Pulse suggest that those with long COVID experience significant reductions in the likelihood of employment, in the 15-30 percentage point range. However, the fundamental empirical challenge is that who gets long COVID is not randomly assigned in the population, so these correlational estimates are not necessarily causal. As depicted in Figure 1, the key concern is that those who developed long COVID may have had other unmeasured characteristics positively correlated with long COVID and negatively correlated with employment: for example, poor general health, pre-existing medical conditions, and behavioral risk factors, such as smoking and obesity. So, simple estimates may be biased. In particular, they may reflect the true effect of long COVID plus the effect of these confounding factors. To circumvent this, richer data are needed.

This portion of the analysis leverages detailed data on health, COVID, and employment behavior from the HRS to estimate the causal impact of long COVID on post-pandemic employment. The sample consists of almost 6,000 individuals, who were 50-75 years old at the start of the pandemic, resided in the U.S., survived the pandemic, and were interviewed in the 2022 wave. About half of these individuals were employed in 2018, prior to the pandemic. Long COVID and employment status are measured in the 2022 wave (which was administered from March 2022, through September 2023) and pre-pandemic medical conditions, risk factors, and labor-market attachment in the 2018 wave, prior to the advent of the novel coronavirus.

Relying on the related medical literature cited in the introduction, a key innovation is to use systemic inflammation to identify and estimate the causal effect of long COVID on employment. The results below show pre-pandemic inflammation, as measured by C-Reactive Protein (CRP), raises the likelihood of experiencing long COVID which translates into a reduction in the likelihood of employment. As illustrated in Figure 2, at a very high level, the basic mechanism is as follows: long COVID is determined by latent baseline physiological vulnerability, either directly or via the severity of the acute phase of the infection. Systemic inflammation acts as an amplifier for vulnerability: those with chronic low-grade inflammation are more vulnerable. The most important innovation in the analysis is the use of a measure of systemic inflammation to identify and estimate the causal effect of long COVID on post-pandemic employment. In particular, pre-pandemic inflammation raises the likelihood of experiencing long COVID which translates into a reduction in the likelihood of employment.

At a more granular level, numerous inflammatory mechanisms have been proposed and studied in the medical literature on COVID, all of which center on some form of immune dysregulation. The HRS data are not rich enough to distinguish between those detailed mechanisms, but do include a standard clinical measure of inflammation, which is C-Reactive Protein, or CRP. It is produced by the liver, found in the bloodstream, and activates the immune system to clear invaders and dead or dying cells. The HRS measured CRP and four other biomarkers (Cystatin C, Total Cholesterol, HDL, and A1c) for respondents in three rounds. The first round occurred in 2006 and 2008.[1] The second round occurred in 2010 and 2012, and the third in 2014 and 2016. Pre-existing systemic inflammation is measured by CRP in Round 3.

Figure 3 is a bin scatter plot of the raw relationship between pre-pandemic inflammation and the likelihood of long COVID, or the first-stage relationship, without any controls. The horizontal axis measures the natural logarithm of CRP from Round 3; the vertical axis measures the prevalence of long COVID. The sample is ranked according to CRP and divided into 100 groups (or bins) of equal size, and then the percentage of respondents with long COVID in that group is calculated. So, each dot in the scatter represents 1 percent of the sample; moving from left to right in the figure moves from low to high levels of inflammation. The superimposed line illustrates the average linear relationship between the likelihood of long COVID and log CRP, which is positive, consistent with inflammation as an amplifier. Figure 4 is a similar figure, but for acute COVID infection. Infection is an equal opportunity and does not depend on the level of systemic inflammation, but long COVID does.

Next, leaning on the medical literature, Figure 3 is re-drawn after having accounted for a large number of other factors that have been shown to be correlated with long COVID, inflammation, or both to isolate the independent effect of inflammation on long COVID. These factors are as follows: age, race, sex, ethnicity, education, marital status, region, and the timing (month and year) of the interview. These factors are all measured in the Census Pulse. In addition, a large array of medical and behavioral risk factors, as well as pre-pandemic labor force attachment are included: the presence of medical conditions (heart disease, diabetes, high blood pressure, stroke, psychiatric, lung disease, cancer, and arthritis), behavioral risk factors (obesity, smoking, sleep problems, depression), pre-pandemic employment, the other biomarkers measured in Round 3 (Cystatin C, Total Cholesterol, HDL, A1c), and the measure of COVID transmissibility (the weighted-average R0 of the virus for the HRS interview week based on the CDC's estimates of the proportion of variants in circulation that week in the individual's Census division). These additional factors are not available in the Census Pulse, but are through the richness of the HRS. Figure 5 shows the first-stage relationship after having accounted for these additional factors. It is essentially the same: higher levels of inflammation are associated with a greater likelihood of long COVID.

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[1] Roughly half of HRS respondents in 2006 and the remainder in 2008.

Given these results, if long COVID truly reduces employment, then there should be a negative relationship between inflammation and post-pandemic employment in the reduced form. And, indeed, there is. Figure 6 is a bin scatter plot of the likelihood of post-pandemic employment on log CRP, controlling for the same factors as in Figure 5 listed above. There is a clear negative reduced-form relationship.

Furthermore, this relationship is only present for the pandemic. In particular, Figure 7 repeats Figure 6, but instead uses inflammation and subsequent employment wholly in the pre-pandemic period, as measured in rounds 1 and 2 of biomarker collection. These occurred well before the pandemic. If inflammation is the amplifier for the novel coronavirus, then there should be no relationship between the two measured in the pre-pandemic period. And, indeed, that is the case in Figure 7. This falsification test lends credence to the basic mechanism laid out in Figure 2.

Column 1 of Table 4 shows the marginal effect from instrumental variable probit estimation of the impact of long COVID on employment in 2022-2023. These estimates effectively combine the reduced-form and first-stage estimates from Figures 5 and 6, using ln(CRP) as an instrument for long COVID. This specification includes controls for age, race, sex, ethnicity, education, marital status, region, timing (month and year) of the interview, the presence of medical conditions (heart disease, diabetes, high blood pressure, stroke, psychiatric, lung disease, cancer, and arthritis), behavioral risk factors (obesity, smoking, sleep problems, depression), pre-pandemic employment, the other biomarkers measured in Round 3 (Cystatin C, Total Cholesterol, HDL, A1c), the measure of COVID transmissibility used in those figures. The estimated marginal effect of long COVID is to reduce the likelihood of employment by 9 percentage points. With a standard error of 1.8 percentage points, this effect is statistically different than zero and smaller than the sparse existing estimates based on other data sources like Census Pulse. Roughly half of these 50-75 year olds were employed prior to the pandemic. So, a 9 percentage-point reduction on a base of 50 percentage points is a substantive economic effect. This translates into a 10 percent decline in annual earnings (relative to prior to the pandemic).

Furthermore, columns 2-3 break out this reduction into that related to full-time and part-time employment, respectively, based on an isomorphic instrumental variable ordered probit specification. Most of the decline in employment is from a reduction in full-time work: 7.6 percentage points of the 9 percentage-point decline.

Implications and Caveats

To the extent that these employment effects are persistent, long COVID may end up a gateway to accelerated labor force exit and OASDI claiming. To explore this, columns 1-2 of Table 5 present the marginal effects of long COVID on self-reported retirement status from instrumental variable probit estimation akin to that in Table 4. Column 1 measures complete or full retirement; column 2 measures partial retirement. Note that employment in Table 4 is defined as working for pay; retirement here is self-identified. They are not mutually exclusive: one can identify as retired (from, for example, a career job), but still be working for pay. In Column 1 of Table 5, long COVID raises the likelihood of reporting being fully retired by 17 percentage points, an economically large and statistically significant effect. Some of this effect is offset by a reduction in the likelihood of identifying as partially retired (of 3 percentage points in column 2).

Column 3 then looks to see if this manifested itself in the likelihood of receipt of Social Security benefits in 2022-2023, defined as OASDI benefits. Long COVID is associated with an estimated increase in the likelihood of benefit receipt of 8 percentage points, but that effect is not statistically different from zero at conventional levels of significance. Finally, column 4 examines the expected claiming age for those who have yet to claim OASDI benefits. Again, long COVID is associated with an estimated decrease in the age of claiming of 2.4 years, but that effect is not statistically different from zero at conventional levels of significance. Overall, the implications for Social Security claiming are equivocal.

These conclusions are tempered by the following caveats. First, the estimated impacts of long COVID are for 2022-2023 and, therefore, should be viewed as short run in nature. It could be that implications for OASDI claiming behavior take longer to develop. Data for the next wave of the HRS, which is 2024 and currently in the field, will be critical to understanding these effects. Second, the analysis uses a sample of individuals who were 50-75 years old, i.e., later career workers. Long COVID is comparatively more prevalent in younger workers, particularly in their 40s. The estimates herein leave the impacts for younger workers unaddressed, which is important when considering the effect of long COVID on the DI program.

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Table 1. *Mean of Selected Variables in the HRS Analysis Samples, Standard Deviation in Parentheses*

Variable:	(1) Full	(2) With Health Care Disruptions	(3) Without Health Care Disruptions	(4) Difference: Columns (2)-(3)	(5) With Long COVID	(6) Without Long COVID	(7) Difference: Columns (5)-(6)
A. Demographic Characteristics							
Female	0.594	0.647	0.569	0.078***	0.659	0.589	0.070***
White	0.603	0.616	0.597	0.019*	0.663	0.598	0.065***
Black	0.252	0.250	0.253	-0.003	0.179	0.259	-0.080***
Hispanic	0.185	0.166	0.195	-0.029***	0.228	0.181	0.047***
High School Diploma	0.281	0.244	0.299	-0.055***	0.302	0.279	0.022
Some College	0.293	0.307	0.286	0.021**	0.346	0.288	0.058***
College Graduate	0.292	0.339	0.269	0.070***	0.239	0.297	-0.058***
Married	0.664	0.623	0.684	-0.061***	0.663	0.664	-0.001
Age (months)	741	735	745	-9***	724	743	-19***
	(72)	(70)	(72)		(71)	(72)	
B. Pre-Pandemic Medical Conditions and Behavior Risk Factors							
Diabetes	0.263	0.271	0.259	0.012	0.275	0.262	0.014
Heart Disease	0.184	0.208	0.173	0.035***	0.234	0.180	0.054***
Arthritis	0.527	0.572	0.505	0.067***	0.618	0.518	0.100***
Lung Disease	0.100	0.126	0.087	0.039***	0.136	0.096	0.040***
Psychiatric Conditions	0.234	0.317	0.194	0.123***	0.286	0.230	0.056***
High Blood Pressure	0.570	0.583	0.564	0.019	0.608	0.567	0.041*
Brain-Related Condition	0.064	0.068	0.062	0.006	0.063	0.064	-0.001
Cancer	0.121	0.126	0.119	0.007	0.122	0.121	0.001
Obese	0.436	0.451	0.428	0.023**	0.517	0.428	0.089***
Depression Score	1.506	1.934	1.300	0.634***	1.943	1.467	0.476***
	(2.046)	(2.319)	(1.867)		(2.172)	(2.030)	
Smokes	0.151	0.158	0.148	0.010	0.126	0.153	-0.027*
Has Health Insurance	0.556	0.555	0.556	-0.001	0.542	0.557	-0.015
Number of Persons	8,351	2,712	5,639		683	7,668	

Notes: Column 1 presents the unweighted mean of the variable for the HRS analysis sample of 8,351 persons described in the text. Standard deviations for continuous variables are shown in parentheses. Columns 2 and 3 split the sample by whether they experienced a pandemic-related delay in health care, with difference between the subsamples shown in column 4. Columns 5 and 6 split the sample by whether they had long covid, with difference between the subsamples shown in column 7. *** indicates the difference is statistically significant at less than or equal to 1 percent level; ** at the 1-5 percent level; and * at the 5-10 percent level, respectively.

Table 2. *Probit Marginal Effects for Association of Demographic and Pre-Pandemic Health Characteristics with Health Care Disruptions and Long COVID, Respectively (Standard Errors in Parentheses)*

	(1)	(2)
	Dependent Variable:	
Explanatory Variable:	Health Care Disruption	Long COVID
Female	0.047***	0.013**
	(0.011)	(0.006)
White	0.027	0.013
	(0.017)	(0.009)
Black	0.011	-0.026**
	(0.020)	(0.010)
Hispanic	-0.021	0.017*
	(0.017)	(0.010)
High School Diploma	0.026	0.026**
	(0.019)	(0.011)
Some College	0.096***	0.039***
	(0.020)	(0.012)
College Graduate	0.160***	0.013
	(0.021)	(0.012)
Married	-0.028**	0.004
	(0.012)	(0.006)
Age (months)	-0.00045***	-0.00032
	(0.00008)	(0.00004)
Diabetes	0.005	-0.003
	(0.012)	(0.007)
Heart Disease	0.021*	0.015**
	(0.012)	(0.006)
Arthritis	0.038***	0.029***
	(0.011)	(0.006)
Lung Disease	0.035**	0.013*
	(0.015)	(0.008)
Psychiatric Conditions	0.069***	-0.005
	(0.012)	(0.007)
High Blood Pressure	0.012	0.009*
	(0.010)	(0.006)
Brain-Related Condition	-0.030	-0.013
	(0.021)	(0.011)
Cancer	0.003	-0.001
	(0.013)	(0.008)
Obese	0.005	0.015
	(0.011)	(0.006)
Depression Score	0.026***	0.005***
	(0.003)	(0.001)
Smokes	-0.005	-0.024***
	(0.015)	(0.007)
Has Health Insurance	-0.009	-0.010
	(0.012)	(0.006)

Notes: Columns 1 and 2 present probit marginal effects when the dependent variable is ever having had a pandemic-related health care disruption and long COVID, respectively. Standard errors are in parentheses. *** indicates the estimate is statistically significant at less than or equal to 1 percent level; ** at the 1-5 percent level; and * at the 5-10 percent level, respectively.

Table 3. *Probit Marginal Effects for the Effect of Health Care Disruptions on Late-Pandemic Employment (Standard Errors in Parentheses)*

	(1)	(2)	(3)
	Dependent Variable:		
Explanatory Variable:	Employed in 2022-23	Employed in 2022-23	Employed in 2022-23
Health Care Disrupted	-0.006	0.0007	-0.00004
	(0.011)	(0.013)	(0.014)
Fraction Employed in 2022-23	0.413	0.413	0.413
Fraction Employed Pre-Pandemic	0.529	0.529	0.529
Additional Controls			
Had COVID, Had Long COVID	Yes	Yes	Yes
Demographics, Region, and Calendar Time	No	Yes	Yes
Pre-Pandemic Medical Conditions, Behavioral Risk Factors, and Health Insurance Coverage	No	Yes	Yes
Employed Pre-Pandemic	No	No	Yes

Notes: Each column presents marginal effects and standard errors from a separate probit maximum likelihood estimation when the dependent variable is employed in 2022-23 (which is the 2022 wave of the HRS). The columns differ by what control variables (shown at the bottom of the table) were included.

Table 4. *Instrumental Variable Probit Marginal Effects for the Effect of Long COVID on Late-Pandemic Employment (Standard Errors in Parentheses)*

	(1)	(2)	(3)
	Dependent Variable:		
Explanatory Variable:	Employed in 2022-23	Employed Part-Time in 2022-23	Employed Full-Time in 2022-23
Long COVID	-0.090	-0.014	-0.076
	(0.018)	(0.004)	(0.015)
Fraction Employed Pre-Pandemic	0.506	0.169	0.334
Additional Controls			
Had COVID	Yes	Yes	Yes
Demographics, Region, and Calendar Time	Yes	Yes	Yes
Pre-Pandemic Medical Conditions, Behavioral Risk Factors, and Health Insurance Coverage	Yes	Yes	Yes
Employed Pre-Pandemic	Yes	No	Yes

Notes: Column 1 presents the marginal effect and associated standard error on the impact of long COVID from a probit maximum likelihood estimation on a sample of 5,799 individuals when the dependent variable takes on a value of 1 if employed in 2022-23 (which is the 2022 wave of the HRS), instrumenting with ln(CRP). Columns 2-3 shows the same but for an ordered probit for which the dependent variable is not employed, employed part-time, or employed full-time.

Table 5. *Instrumental Variable Probit Marginal Effects for the Effect of Long COVID on Retirement Outcomes (Standard Errors in Parentheses)*

	(1)	(2)	(3)	(4)
	Dependent Variable:			
Explanatory Variable:	Completely Retired in 2022-23	Partly Retired in 2022-23	Receiving Social Security Benefits in 2022-23	Expected Claiming Age in 2022-23
Long COVID	0.176	-0.031	0.080	-2.40
	(0.018)	(0.005)	(67.8)	(4.66)
Additional Controls				
Had COVID	Yes	Yes	Yes	Yes
Demographics, Region, and Calendar Time	Yes	Yes	Yes	Yes
Pre-Pandemic Medical Conditions, Behavioral Risk Factors, and Health Insurance Coverage	Yes	Yes	Yes	Yes
Employed Pre-Pandemic	Yes	No	Yes	Yes

Notes: Columns 1-2 present the marginal effects and associated standard errors on the impact of long COVID from a probit maximum likelihood estimation on a sample of 5,796 individuals for which the dependent variable is fully retired, partly retired, or not retired in 2022-23 (which is the 2022 wave of the HRS), instrumenting with ln(CRP). Columns 3 and 4 show the marginal effect and associated standard error from similar, but separate probit estimations.

Figure 1. *Illustration of Omitted Variable Bias on Impact of Long COVID on Employment*

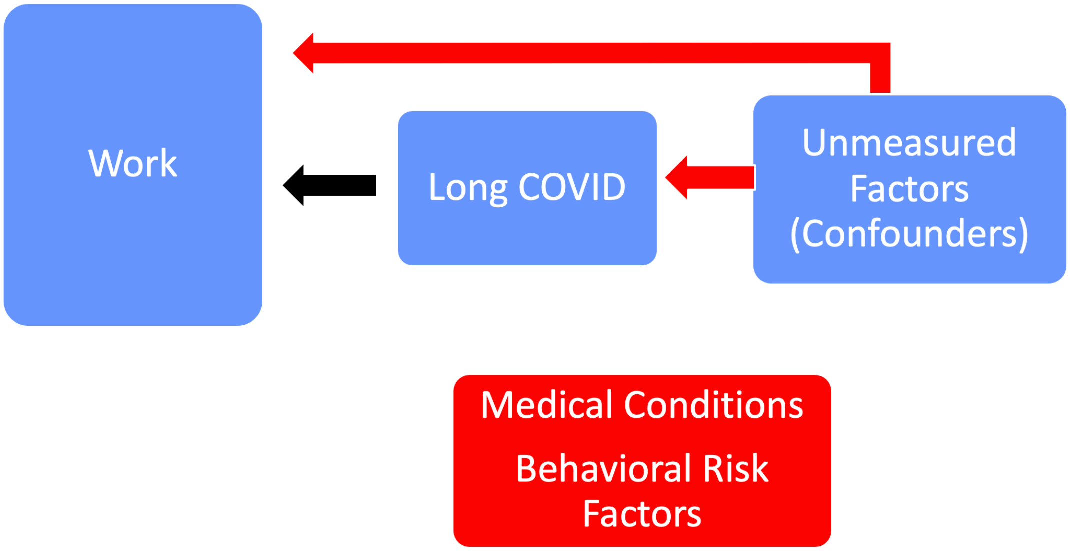


Figure 2. *Possible Pathways from Acute to Long COVID*

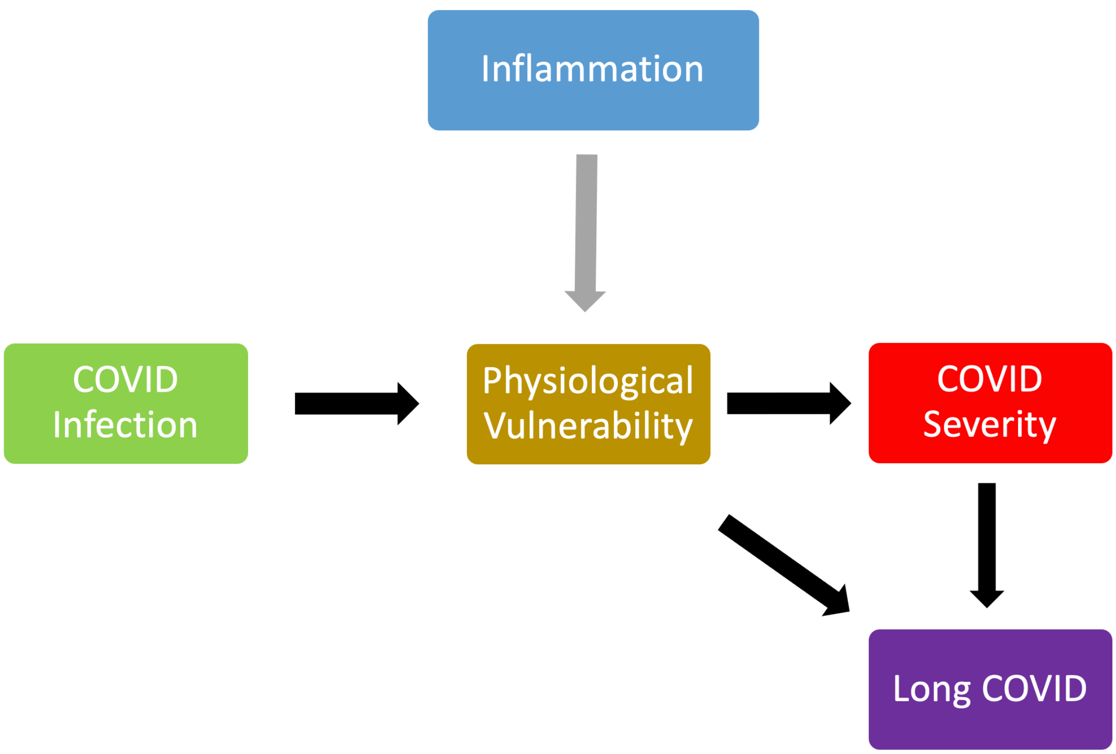


Figure 3. Long COVID and Pre-Pandemic Inflammation

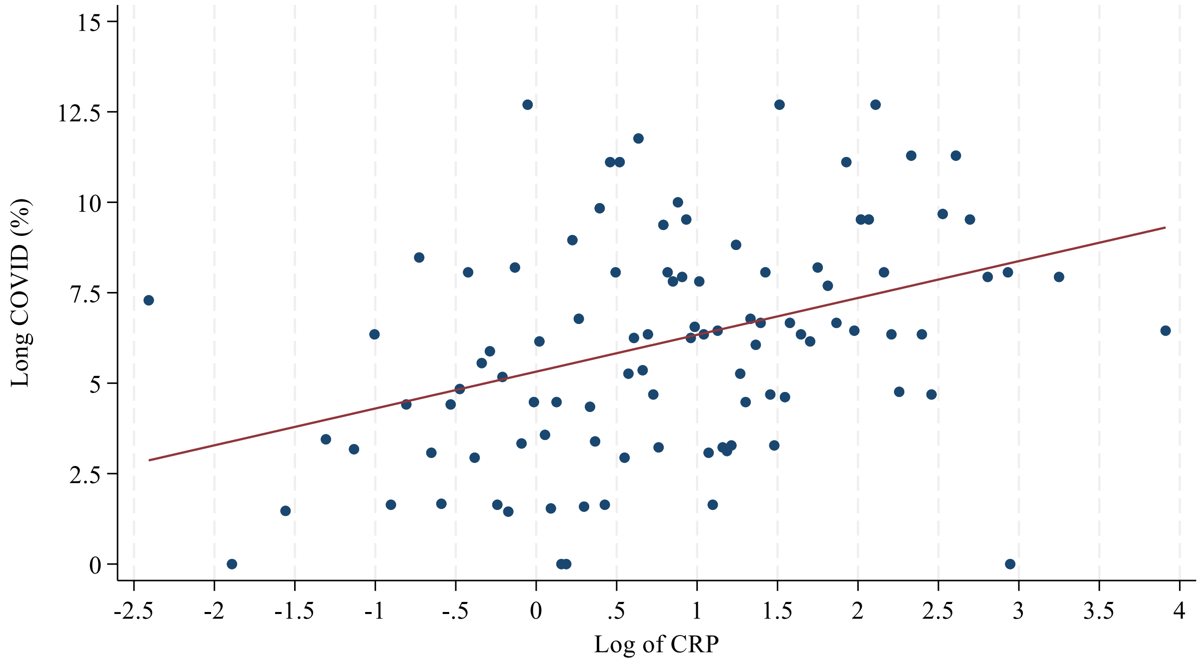


Figure 4. Acute COVID and Pre-Pandemic Inflammation

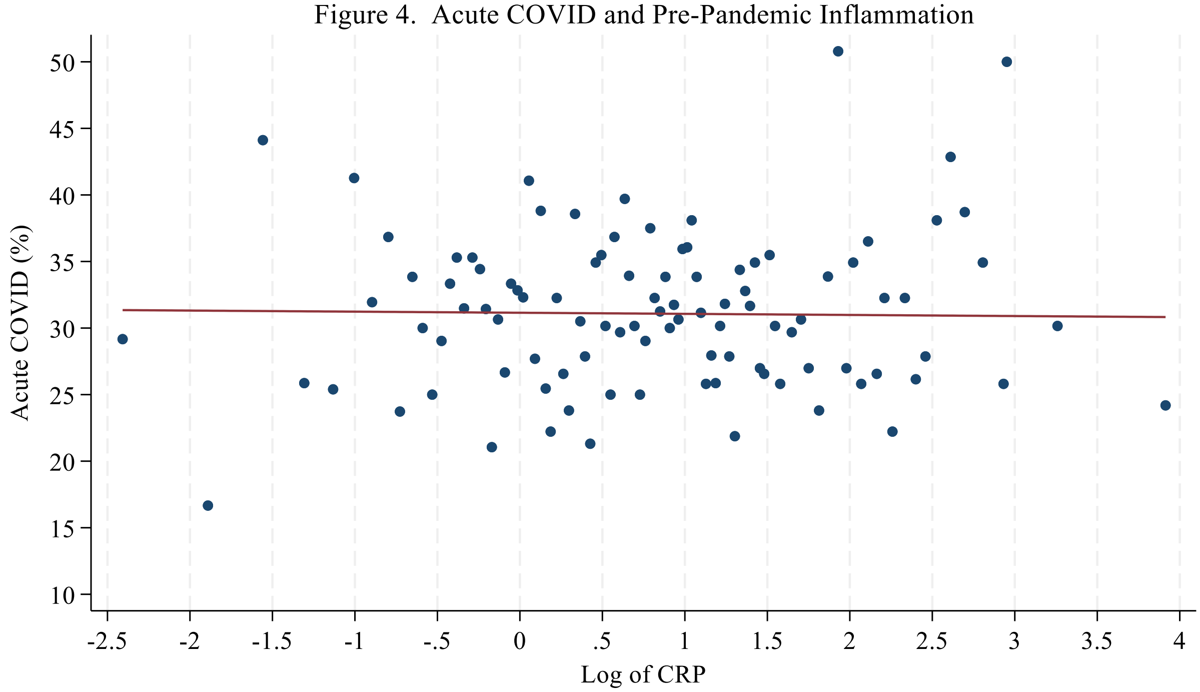


Figure 5. Long COVID and Pre-Pandemic Inflammation, Controlling for Other Factors

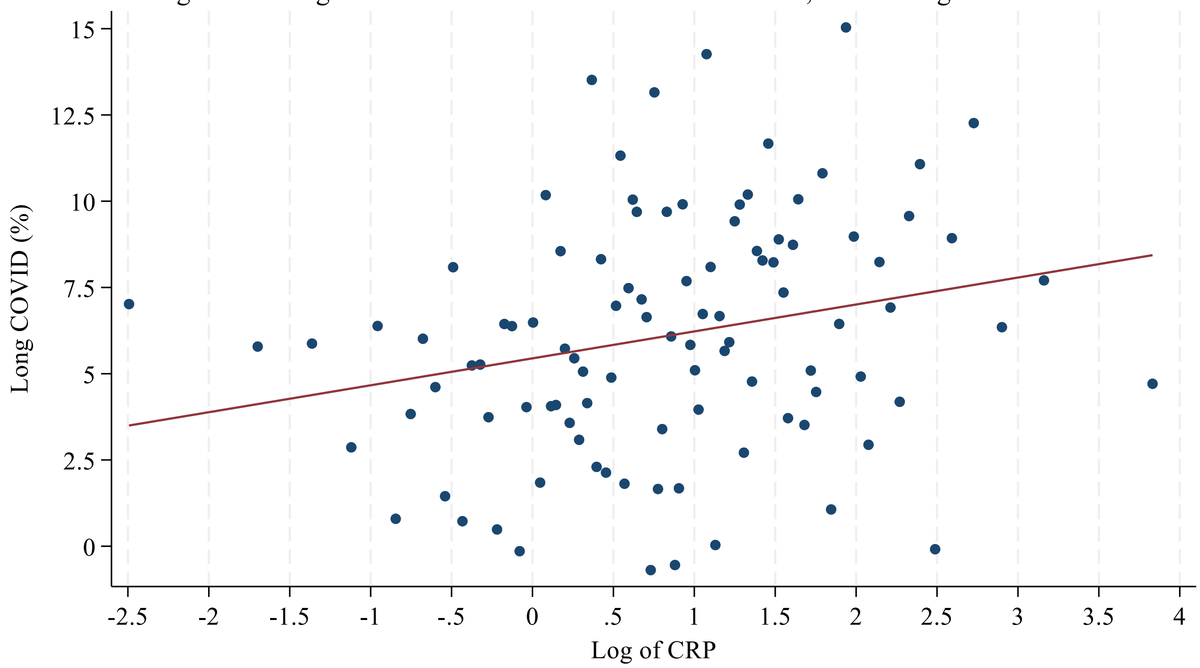


Figure 6. Post-Pandemic Employment and Pre-Pandemic Inflammation, Controlling for Other Factors

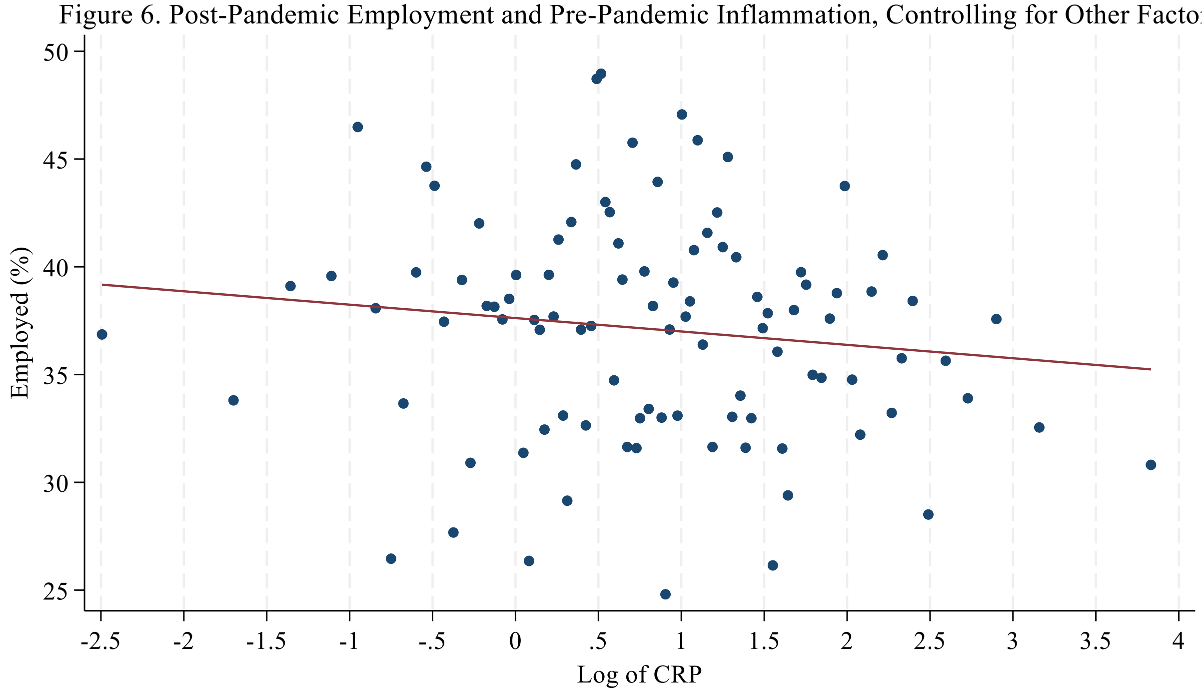
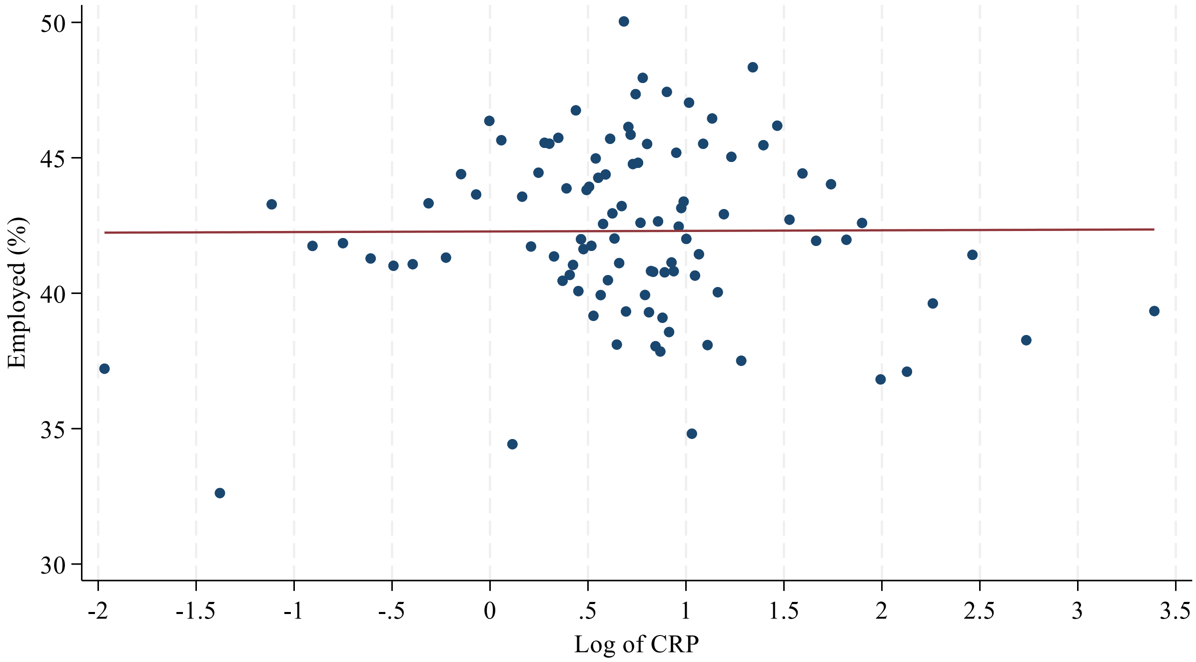


Figure 7. Pre-Pandemic Employment and Pre-Pandemic Inflammation, Controlling for Other Factors



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