INTRODUCTION

The concentration of economic activity in urban areas has substantial benefits including increased productivity and better consumption opportunities (Couture & Handbury, 2020; Del Carpio & Patrick, 2021; Diamond, 2016; Duranton, 2016; Glaeser et al., 2001; Glaeser & Maré, 2001; Lee, 2010; Roca & Puga, 2017). However, there are also potential disadvantages of urbanization including longer commutes, higher housing costs, increased income inequality, and decreased happiness (Combes et al., 2019; Duranton & Puga, 2020; Glaeser, 2020; Glaeser et al., 2009, 2016; Winters &...
Li, 2017). The recent and rapid spread of SARS-CoV-2, the novel coronavirus that causes COVID-19, was initially most severe in densely populated urban areas (Desmet & Wacziarg, 2021). Concentrating people in small spaces facilitates interactions that are valuable for the spread of knowledge and ideas but also accelerates virus transmission. The COVID-19 pandemic led to massive business closures and reduced economic activity across the globe as governments, firms, and individuals tried to slow the spread of the disease and reduce their own exposure. Unemployment in the United States rose to levels not experienced since the Great Depression (BLS, 2020). Many individuals also exited the labor force or became temporarily absent from work (Cho et al., 2020; Cho & Winters, 2020; Coibion et al., 2020).

In this paper, we examine how the COVID-19 pandemic effects on employment differ between metropolitan and non-metropolitan areas and based on the size of the metropolitan area. We use individual-level data from the Current Population Survey (CPS). The higher early infection rates in more populous metropolitan areas are expected to cause more severe early employment losses, and the early exposure and greater future vulnerability may have scarring effects that lead to persistently greater employment reductions in large MSAs. However, less populated areas eventually surpassed large metropolitan areas in COVID-19 infection rates, partially attributable to less strict mitigation efforts. Thus, the evolution of employment differences across MSA status and size is unclear a priori. Other factors besides virus transmission and vulnerability may also affect employment losses across metropolitan area status and size including individual characteristics and the industry and occupational mix of local jobs.

We first document systematic differences in employment rate reductions by MSA status and population size. Large employment losses during April and May 2020 were experienced in non-metropolitan areas and MSAs of all sizes, but the largest MSAs were hardest hit. Additionally, the unemployment rate regularly understates non-employment (Feng & Hu, 2013; Jones & Riddell, 1999), and the extent worsened during the COVID-19 pandemic in ways that differ across MSA status and size. Our preferred job loss measure is the year-over-year change in the percentage of the civilian adult population employed and at work.1 From April 2019 to April 2020, the employed at work rate fell by 9.6% points in non-metropolitan areas and by 14.6% points in MSAs with more than five million people. All MSA status and size groups experienced partial employment recoveries after April 2020, but employment levels were still significantly below pre-pandemic levels through October 2020.2 Furthermore, the largest MSA group had significantly larger year-over-year employment reductions than non-MSAs in every month from April 2020 to October 2020, despite higher COVID-19 infection rates in non-MSAs than large MSAs in September and October 2020.

We also examine the extent to which the greater employment reductions in large metropolitan areas are due to observable individual and local area characteristics. Large MSAs have higher percentages of college graduates and racial and ethnic minorities. College graduates have lower job loss rates than those with less education, but Blacks and Hispanics experience higher job loss rates than whites (Adams-Prassl et al., 2020; Cho & Winters, 2020; Mongey et al., 2020). These factors have roughly offsetting effects on differences in employment losses across MSA status and size. Controlling for individual education, race, ethnicity, age, sex, marital status, and children still yields much larger employment losses in large MSAs than in less populous areas. We also find evidence that the local industry mix matters. Most notably, areas with higher pre-pandemic employment shares in leisure and hospitality suffered greater employment losses during the early months of the pandemic.

We find that the local COVID-19 infection rate is a major factor explaining early differences in employment reductions across MSA status and size. By September–October 2020, the COVID-19 infection rate is still a significant impediment to employment, but the higher infection rates in less populous areas mean that contemporaneous infections do not explain the worse relative employment
outcomes in large MSAs during these months. However, we also find evidence of persistent effects of early COVID-19 infection rates on later employment. Specifically, the local COVID-19 infection rate in March 2020 has a significant negative effect on employment in September–October 2020.

Our paper contributes to the important and rapidly growing research literature on impacts of COVID-19. Previous literature has documented large employment losses (Cajner et al., 2020; Chetty et al., 2020; Cho & Winters, 2020). However, the extant literature has not focused on differing employment impacts across metropolitan area status and population size. Furthermore, we use individual-level data, which facilitate insights not possible with aggregate county or MSA data more commonly used in regional science. Specifically, using individual-level data has three main advantages. First, it allows us to account for increased prevalence of persons who report having a job but are temporarily absent from work. Second, it allows us to examine the extent to which individual characteristics directly explain greater employment reductions in large MSAs; we find that average differences across areas are not driven by differing individual characteristics. Third, we split the sample by education level to explore heterogeneous effects. The spatial pattern of employment losses are largely similar for low and high education workers early in the pandemic, but less educated workers in medium and large population MSAs appear to have experienced especially persistent job losses later in the pandemic. We make an important empirical contribution for understanding the economic impacts of COVID-19 across areas.

The COVID-19 pandemic also raises issues about the future of cities, regions, and work (Autor, 2019; Clancy, 2020; Delventhal et al., 2020; Gaspar & Glaeser, 1998; Glaeser et al., 2018). Future viruses may pose even greater risks, especially for highly populous metropolitan areas that exist to concentrate people and workers in relatively small spaces. Increased work from home may be a lasting legacy of COVID-19 that considerably alters economic production and where it occurs.

2  |  DATA

2.1  |  Overview

We use individual-level data from the U.S. CPS accessed from IPUMS (Flood et al., 2020). Each month the CPS surveys roughly 60,000 households about their labor market activity, demographics, and other characteristics. The CPS is used by the Bureau of Labor Statistics (BLS) to compute the monthly unemployment rate, labor force participation rate, and related measures for the U.S. Based on responses to multiple CPS questions, the BLS classifies civilians aged 16 and over as employed, unemployed, or not in the labor force (BLS, 2020). Employed individuals are further separated into those at work during the survey reference week and those with a job but temporarily absent from work. An individual is considered employed at work if they worked at all for pay or profit during the survey reference week or worked unpaid for at least 15 hr in a family business; this includes persons working from home. Persons who have a job but are temporarily absent include persons on vacation, out sick, or taking a temporary leave of absence; it is not intended to include persons on temporary layoff, but there is some apparent misreporting on this (BLS, 2020). An individual is defined as unemployed if they did not work but were willing and able to work and looked for work during the past four weeks or were temporarily laid off. Persons who are neither employed nor unemployed are defined as not in the labor force. The CPS also includes information on individuals’ age, education, race, ethnicity, sex, marital status, and presence of own children living in the household.

The CPS includes individuals residing in 260 identifiable metropolitan statistical areas (MSAs). For individuals not living in a metropolitan area, the CPS identifies the state of residence but not the
county. A small percentage of individuals in the CPS (4.3% for our sample period) live in a small metropolitan area that is not identified or an area that cannot be identified as either metropolitan or non-metropolitan in order to protect individual confidentiality; these observations are necessarily excluded from our analysis. Given the available CPS geographic identifiers, we define local areas as individually identifiable MSAs and state-specific non-metropolitan residuals. Individuals living in metropolitan areas are also classified based on year 2019 population into the following MSA population size categories: 100,000–250,000; 250,000–500,000; 500,000–1,000,000; 1,000,000–2,500,000; 2,500,000–5,000,000; and 5,000,000 or larger. We label these as 100–250 K, 250–500 K, 500 K–1 M, 1–2.5 M, 2.5–5 M, and 5 M+. We also obtain data for local area characteristics from other sources. This includes COVID-19 confirmed positive cases by county and month obtained from USAFacts (2020). We sum the data by local area (individually identifiable MSA or state non-MSA residual) and divide by local area population to compute the percentage of the local population that tested positive in a given month. We also measure local labor market characteristics using data from the 2016–2018 CPS. We use the Dingel and Neiman (2020) measure for which occupations can be done from home to compute the percentage of occupations that can be done remotely for each local area in 2016–2018. We construct eight variables measuring the industrial structure in each local area computed as the 2016–2018 percentage of local employment in various industries. The industrial structure variables include the percentages of employment in (a) agriculture; (b) mining; (c) construction; (d) transportation and utilities; (e) wholesale and retail trade; (f) professional, business, information, and financial services; (g) education and health services; (h) leisure and hospitality; (i) other services; and (j) public administration. The omitted industry category is manufacturing.

Sub-sample means for selected explanatory variables are in Table 1. Individual characteristics and local area characteristics vary across MSA status and size in important ways. Non-MSAs are the oldest and mean age decreases with MSA population. The percentage female does not systematically vary. The percentages of Hispanics, Blacks, and Asians increase with MSA status and size. Bachelor's degree attainment rates increase with MSA status and size. The percentage married decreases with MSA status and size, but the percentage with kids in the household increases. The infection rate variable is measured in logs, so the means are negative for all groups. The March 2020 infection variable mean increases (becomes less negative) with MSA status and population size group, with substantial differences between the most populous MSA group and least populous areas. The largest MSA group had the highest infection means early in the pandemic, and they continued with the highest infection means through June 2020 before being surpassed by most other groups in July 2020. The second largest MSA group also had the second highest infection variable mean from March 2020 to June 2020. While non-MSAs and smaller MSAs initially had the lowest infection means, this did not last. By September 2020, the non-MSA group had the highest infection variable mean and they maintained this position in October 2020. The two smallest MSA groups also had the next highest infection means in September and October. Conversely, the two largest MSA population groups had the lowest infection variable means among the seven groups in September and October 2020. Thus, the infection-population size gradient flipped sign during our sample period. The virus spread was initially most severe in large MSAs but eventually least severe in large MSAs. This is important to recall when considering the effects of local infection rates on employment differences across MSA status and size.

The percentage of occupations that can be done from home increases with MSA status and size. The industrial structure varies some, but the differences are often relatively small and not systematic. As expected, the mean employment percentages in agriculture and mining are highest in non-MSAs and generally decrease with MSA size. The percentage in professional, business, information, and financial services (collectively referred to as professional services) increases significantly with MSA...
**TABLE 1** Sub-sample means for selected explanatory variables by MSA status and size

| Individual characteristics | Non-metro | MSA Pop. 100−250 K | MSA Pop. 250−500 K | MSA Pop. 500 K−1 M | MSA Pop. 1−2.5 M | MSA Pop. 2.5−5 M | MSA Pop. 5 M+ |
|-----------------------------|-----------|--------------------|--------------------|--------------------|-----------------|-----------------|----------------|
| Age                         | 49.35     | 47.74              | 47.07              | 46.83              | 46.21           | 45.91           | 45.80          |
| Female                      | 0.513     | 0.520              | 0.520              | 0.517              | 0.518           | 0.512           | 0.517          |
| Hispanic                    | 0.067     | 0.106              | 0.159              | 0.170              | 0.135           | 0.178           | 0.268          |
| Black                       | 0.079     | 0.098              | 0.113              | 0.098              | 0.138           | 0.100           | 0.165          |
| Asian                       | 0.009     | 0.026              | 0.028              | 0.050              | 0.062           | 0.095           | 0.100          |
| Native American             | 0.019     | 0.008              | 0.004              | 0.008              | 0.004           | 0.005           | 0.002          |
| Hawaiian/Pacific Islander   | 0.002     | 0.003              | 0.002              | 0.005              | 0.004           | 0.004           | 0.002          |
| Two or more races           | 0.014     | 0.014              | 0.018              | 0.018              | 0.017           | 0.018           | 0.011          |
| High School Diploma         | 0.367     | 0.311              | 0.295              | 0.281              | 0.264           | 0.237           | 0.245          |
| Some College                | 0.284     | 0.291              | 0.291              | 0.276              | 0.268           | 0.266           | 0.233          |
| Bachelor's Degree or Higher | 0.202     | 0.277              | 0.290              | 0.321              | 0.360           | 0.389           | 0.388          |
| Married                     | 0.539     | 0.526              | 0.507              | 0.510              | 0.506           | 0.505           | 0.494          |
| Has Kids in Household       | 0.326     | 0.338              | 0.346              | 0.351              | 0.352           | 0.358           | 0.374          |

**Local area characteristics**

| Ln COVID-19 Rate March      | −4.54     | −4.49              | −4.23              | −3.87              | −3.62           | −3.38           | −2.77          |
| Ln COVID-19 Rate April     | −2.43     | −2.55              | −2.39              | −2.22              | −2.15           | −1.83           | −1.05          |
| Ln COVID-19 Rate May       | −2.18     | −2.38              | −2.24              | −2.19              | −2.17           | −1.82           | −1.19          |
| Ln COVID-19 Rate June      | −1.97     | −2.07              | −1.66              | −1.59              | −1.56           | −1.52           | −1.39          |
| Ln COVID-19 Rate July      | −1.15     | −1.10              | −0.80              | −0.81              | −0.68           | −0.88           | −0.91          |
| Ln COVID-19 Rate August    | −1.01     | −1.14              | −0.97              | −1.04              | −1.01           | −1.11           | −1.07          |

(Continues)
| Non-metro | MSA Pop. 100–250 K | MSA Pop. 250–500 K | MSA Pop. 500 K–1 M | MSA Pop. 1–2.5 M | MSA Pop. 2.5–5 M | MSA Pop. 5 M+ |
|-----------|--------------------|--------------------|--------------------|-----------------|-----------------|--------------|
| Ln COVID-19 Rate September | −0.97 | −1.16 | −1.00 | −1.20 | −1.18 | −1.44 | −1.34 |
| Ln COVID-19 Rate October | −0.37 | −0.68 | −0.64 | −0.75 | −0.82 | −0.97 | −0.94 |
| % Occ. Can Work from Home | 29.08 | 34.36 | 35.88 | 38.56 | 42.10 | 44.97 | 43.89 |
| % Employed in Agriculture | 5.92 | 2.11 | 2.35 | 1.52 | 0.68 | 0.46 | 0.24 |
| % Employed in Mining | 1.11 | 0.86 | 0.63 | 0.31 | 0.33 | 0.13 | 0.40 |
| % Employed in Construction | 7.40 | 6.70 | 6.89 | 7.17 | 6.87 | 6.64 | 7.08 |
| % Emp. Wholesale/Retail | 13.38 | 13.91 | 13.66 | 13.83 | 13.21 | 12.82 | 12.84 |
| % Emp. Transport./Utilities | 5.38 | 4.57 | 4.71 | 4.74 | 5.32 | 5.15 | 6.25 |
| % Emp. Professional Services | 11.88 | 15.16 | 17.20 | 19.60 | 22.57 | 25.17 | 25.31 |
| % Emp. Education/Health | 23.06 | 24.85 | 23.66 | 23.49 | 22.05 | 21.86 | 21.57 |
| % Emp. Leisure/Hospitality | 8.01 | 9.74 | 9.92 | 9.26 | 10.24 | 9.27 | 9.24 |
| % Emp. Other Services | 4.59 | 4.75 | 5.15 | 4.82 | 4.68 | 4.77 | 5.30 |
| % Emp. Public Admin. | 5.34 | 5.29 | 4.78 | 4.74 | 4.55 | 4.31 | 4.23 |

**Note:** The sample includes 1,156,146 individuals age 16 and over in the 2019–2020 April–October CPS.
status and size. While not explicit in the table, the manufacturing employment share (the omitted group) systematically decreases with MSA status and size.

2.2 Changes over time by MSA status and size

Figure 1 illustrates the monthly unemployment rate, labor force participation rate, and employed at work rate for January 2019 through October 2020 for non-metropolitan areas and for MSAs with population 100–250 K, 250–500 K, 500 K–1 M, 1–2.5 M, 2.5–5 M, and 5 M+. Similarly, Table 2 reports 2019–2020 year-over-year rate changes by month and group for unemployment, labor force participation, employment-to-population, having a job but not at work, and employed at work. The unemployment rate is computed as a percentage of the labor force. The other rates are computed as a percentage of the civilian adult population. All estimates use CPS survey weights. We view the employed at work rate as the preferred comprehensive measure because it accounts for changes in unemployment, labor force participation, and temporary absence from work.

Figure 1 shows that the unemployment rate was relatively flat and similar for each group from January 2019 to February 2020. However, the unemployment rate began increasing in March 2020 and exceeded 13% for every group in April 2020. The April 2020 unemployment rate was highest for the three largest MSA population groups and lowest for non-MSAs and the smallest MSA population group. The unemployment rate decreased some in May 2020 as businesses began reopening. The unemployment rate continued declining in subsequent months but was still above pre-pandemic levels for all groups through October 2020. The unemployment rate for MSAs with population 5 M+ remained higher than other groups, and the unemployment rate was consistently lowest for non-MSAs and small MSAs.

The labor force participation rate exhibits notable differences across groups even before COVID-19 hit the U.S. Non-MSAs have the lowest participation rate in every month considered, and the three largest MSA population groups had the highest labor force participation rates. These persistent differences in labor force participation between large and small labor markets may reflect some combination of local differences in labor demand, matching, age structure, and cultural norms. Labor force participation decreased for all groups in April 2020 and began recovering in May 2020, but had not fully recovered by October 2020.

The employed at work rate is lowest for non-MSAs during most periods similar to the labor force participation rate. The three largest MSA population groups had the highest employed at work rates for January 2019 through February 2020, again consistent with the labor force participation rate. All groups experienced declines in employed at work rates during April 2020 and partial recovery beginning in May 2020. The largest MSA population groups experienced the largest declines in employed at work rates.

Table 2 Panel A reports large April and May year-over-year increases in unemployment for non-MSAs and every MSA group, but the differences across groups are striking. Between May 2019 and May 2020, the unemployment rate increased by 6.9% and 7.1% points in non-MSAs and MSAs with population 100–250 K but by 11.6% points in MSAs with population 5 M+. By October, the unemployment rate in the largest MSA group was still 4.7% points higher than the previous year, while the year-over-year increase was only 0.9% points for non-MSAs and only 2.0% points for the smallest MSA group.

Panel B reports significant April year-over-year decreases in labor force participation rates for all groups, with the largest changes for the three largest population MSAs. By October 2020, the year-over-year change was still significantly negative for the two largest MSA groups and for MSAs with population 250–500 K. Panel C reports considerable decreases in the employment-population ratio with differences across MSA status and size and over time qualitatively similar to those for the
unemployment rate and labor force participation rate. Panel D documents that every group experienced increases in the has job not at work rate in April 2020 and the increase was largest for MSAs with population 5 M+, though the magnitude is otherwise not systematic across MSA population.
|                | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|----------------|-----|-----|-----|-----|-----|-----|-----|
|                | Non-metro | MSA Pop. 100–250 K | MSA Pop. 250–500 K | MSA Pop. 500 K–1 M | MSA Pop. 1–2.5 M | MSA Pop. 2.5–5 M | MSA Pop. 5 M+ |
| **A. Unemployment rate** | | | | | | | |
| Jan. 2020–Jan. 2019 | −0.026 | −1.288* | 0.233 | −0.537 | −0.387 | −0.686* | −0.432 |
| Feb. 2020–Feb. 2019 | 0.201 | −0.118 | −0.684 | −0.194 | −0.469 | −0.375 | −0.138 |
| Mar. 2020–Mar. 2019 | −0.092 | 0.422 | −0.353 | 0.501 | 0.814* | 0.576 | 1.277** |
| Apr. 2020–Apr. 2019 | 9.498** | 8.912** | 10.627** | 11.077** | 12.168** | 11.784** | 11.873** |
| May 2020–May 2019 | 6.901** | 7.062** | 9.755** | 8.156** | 10.049** | 10.682** | 11.59** |
| June 2020–June 2019 | 3.766** | 5.337** | 8.232** | 5.518** | 6.766** | 9.022** | 9.844** |
| July 2020–July 2019 | 3.173** | 3.601** | 6.519** | 5.365** | 6.491** | 6.273** | 8.920** |
| Aug. 2020–Aug. 2019 | 2.164** | 1.161 | 4.335** | 3.839** | 5.265** | 5.106** | 6.573** |
| Sep. 2020–Sep. 2019 | 2.141** | 2.113** | 3.950** | 3.160** | 4.259** | 5.168** | 6.039** |
| Oct. 2020–Oct. 2019 | 0.911* | 2.081** | 2.811** | 2.422** | 3.349** | 3.775** | 4.684** |
| **B. Labor force participation rate** | | | | | | | |
| Jan. 2020–Jan. 2019 | 0.621 | −0.571 | −1.540 | 1.272 | −0.148 | 0.024 | 0.052 |
| Feb. 2020–Feb. 2019 | 0.386 | 0.247 | −1.137 | 0.906 | −0.804 | −1.078 | 0.887 |
| Mar. 2020–Mar. 2019 | −1.341* | −0.982 | −1.081 | −0.203 | −0.258 | −1.123 | 0.089 |
| Apr. 2020–Apr. 2019 | −2.423** | −2.379* | −2.274* | −1.717* | −2.929** | −3.630** | −3.025** |
| May 2020–May 2019 | −1.083 | −1.451 | −2.269* | −1.560* | −2.399** | −3.560** | −2.500** |
| June 2020–June 2019 | −0.546 | −0.653 | −1.949* | −0.798 | −2.203** | −2.431** | −1.382 |
| July 2020–July 2019 | 0.196 | 0.935 | −1.685 | −2.557** | −2.668** | −3.186** | −1.057 |

(Continues)
|                      | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|----------------------|-----|-----|-----|-----|-----|-----|-----|
|                      | Non-metro | MSA Pop. 100–250 K | MSA Pop. 250–500 K | MSA Pop. 500 K–1 M | MSA Pop. 1–2.5 M | MSA Pop. 2.5–5 M | MSA Pop. 5 M+ |
| Aug. 2020–Aug. 2019 | −0.042 | −1.096 | −2.021* | −2.017** | −1.737** | −2.296** | −1.722** |
| Sep. 2020–Sep. 2019 | −0.812 | −0.092 | −2.292** | −1.970** | −1.692** | −2.361** | −2.356** |
| Oct. 2020–Oct. 2019 | −1.237 | −1.824 | −2.092* | −1.301 | −1.032 | −1.751** | −1.994** |
| C. Employment-to-population ratio | | | | | | | |
| Jan. 2020–Jan. 2019 | 0.607 | 0.227 | −1.604 | 1.545* | 0.110 | 0.474 | 0.332 |
| Feb. 2020–Feb. 2019 | 0.252 | 0.307 | −0.668 | 0.990 | −0.467 | −0.793 | 0.942 |
| Mar. 2020–Mar. 2019 | −1.229 | −1.189 | −0.812 | −0.510 | −0.776 | −1.452* | −0.744 |
| Apr. 2020–Apr. 2019 | −7.547** | −7.509** | −8.435** | −8.393** | −10.357** | −10.838** | −10.214** |
| May 2020–May 2019 | −4.921** | −5.650** | −7.973** | −6.516** | −8.584** | −10.101** | −9.587** |
| June 2020–June 2019 | −2.691** | −3.848** | −6.845** | −4.200** | −6.384** | −8.112** | −7.578** |
| July 2020–July 2019 | −1.668* | −1.330 | −5.568** | −5.740** | −6.690** | −7.064** | −6.732** |
| Aug. 2020–Aug. 2019 | −1.300 | −1.736 | −4.590** | −4.261** | −5.020** | −5.479** | −5.835** |
| Sep. 2020–Sep. 2019 | −2.009** | −1.355 | −4.585** | −3.830** | −4.338** | −5.590** | −6.091** |
| Oct. 2020–Oct. 2019 | −1.707** | −2.979** | −3.712** | −2.738** | −3.161** | −4.154** | −4.909** |
| D. Has job not at work rate | | | | | | | |
| Jan. 2020–Jan. 2019 | −0.336* | 0.110 | −0.444 | −0.291 | 0.123 | −0.371 | −0.326* |
| Feb. 2020–Feb. 2019 | 0.069 | 0.424 | −0.357 | −0.105 | 0.117 | −0.319 | −0.344* |
| Mar. 2020–Mar. 2019 | 0.109 | 0.433 | 0.367 | 0.193 | 0.819** | 0.625** | 0.598** |

(Continues)
|                | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|----------------|-----|-----|-----|-----|-----|-----|-----|
|                | Non-metro | MSA Pop. 100−250 K | MSA Pop. 250−500 K | MSA Pop. 500 K−1 M | MSA Pop. 1−2.5 M | MSA Pop. 2.5−5 M | MSA Pop. 5 M+ |
| Apr. 2020−Apr. 19 | 2.094** | 2.917** | 3.050** | 2.702** | 2.246** | 1.859** | 4.396** |
| May 2020−May 19   | 1.178** | 1.809** | 1.611** | 1.492** | 1.500** | 1.158** | 1.975** |
| June 2020−June 19 | −0.020  | 0.039  | 0.568  | −0.140  | 0.383  | 0.101  | 0.555** |
| July 2020−July 19 | 0.029   | 0.885* | 0.685  | −0.564  | −0.464 | −0.302 | −0.284  |
| Aug. 2020−Aug. 19 | 0.545*  | 0.380  | 0.379  | −0.440  | 0.306  | −0.109 | 0.314  |
| Sep. 2020−Sep. 19 | 0.350*  | 1.112**| 0.670**| 0.161   | 0.195  | 0.767**| 0.357*  |
| Oct. 2020−Oct. 19 | 0.261   | 0.128  | 0.572* | 0.583** | −0.054 | 0.275  | 0.138  |

**TABLE 2 (Continued)**

|                | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|----------------|-----|-----|-----|-----|-----|-----|-----|
| E. Employed at work rate |
| Jan. 2020−Jan. 19 | 0.942 | 0.117 | −1.161 | 1.837** | −0.014 | 0.844 | 0.658 |
| Feb. 2020−Feb. 19 | 0.183 | −0.117 | −0.311 | 1.095 | −0.585 | −0.474 | 1.287* |
| Mar. 2020−Mar. 19 | −1.338* | −1.622 | −1.179 | −0.703 | −1.595* | −2.076** | −1.342* |
| Apr. 2020−Apr. 19 | −9.641** | −10.426** | −11.485** | −11.095** | −12.603** | −12.698** | −14.610** |
| May 2020−May 19   | −6.099** | −7.466** | −9.584** | −8.008** | −10.084** | −11.259** | −11.562** |
| June 2020−June 19 | −2.671** | −3.887** | −7.413** | −4.060** | −6.767** | −8.214** | −8.134** |
| July 2020−July 19 | −1.698*  | −2.215* | −6.253** | −5.176** | −6.226** | −6.762** | −6.448** |
| Aug. 2020−Aug. 19 | −1.845** | −2.117* | −4.968** | −3.821** | −5.326** | −5.370** | −6.149** |
| Sep. 2020−Sep. 19 | −2.359** | −2.467* | −5.255** | −3.991** | −4.533** | −6.358** | −6.448** |
| Oct. 2020−Oct. 19 | −1.968** | −3.107** | −4.284** | −3.321** | −3.107** | −4.429** | −5.047** |

*Note: The full sample includes civilians age 16 and over.

*Year-over-year change is significantly different from zero at the 5% level; **Significant at 1% level.
The has job not at work rate remained significantly above the previous year in May 2020 but mostly returned to pre-pandemic levels afterward.

Panel E indicates significant April year-over-year decreases in the employed at work rate for every group. The April year-over-year change was 14.6% points in MSAs with population 5 M+ but only 9.6% points in non-MSAs. The May 2019 to May 2020 decrease was 6.1% points for non-MSAs but 11.6% points for the largest MSA group. By October the year-over-year change was still 5.0% points for the largest MSA group but only 2.0% points for non-MSAs. The largest labor markets suffered the largest employment rate decreases from COVID-19, both in the early months and for several subsequent months as labor markets partially recovered.

Our main analysis includes civilians aged 16 and older, but there is some interest in examining a narrower age range with stronger labor market ties. Therefore, we replicated Table 2 restricting the sample to ages 25–61; results are in Appendix Table A1. The results are qualitatively similar, but magnitudes are often larger because the narrower sample has higher baseline employment rates.

There is also interest in how individual metropolitan areas were affected. CPS sample sizes are not very large for smaller MSAs, which prevents precise estimates. However, sample sizes are sufficient for somewhat precise estimates for larger MSAs. Appendix Table A2 reports employed at work rate year-over-year changes for the 50 largest population MSAs. For April year-over-year changes, Las Vegas was the hardest hit among the 50 largest MSAs followed by Detroit and New Orleans. Las Vegas and New Orleans were hard hit because of their reliance on leisure and hospitality industries, while Detroit is heavily reliant on automobile manufacturing.

3 | EMPIRICAL METHODS

We estimate linear probability models to assess the importance of individual and local area characteristics for explaining differences in employment impacts across MSA status and size. Specifically, we estimate the following difference-in-differences (DD) regression models:

\[
Y_{iat} = \gamma_{\text{MSAGroup}_a \times 2020} + \theta_{\text{LocArea}_a} + \alpha_{2020} + \epsilon_{iat} \tag{1}
\]

\[
Y_{iat} = \gamma_{\text{MSAGroup}_a \times 2020} + \theta_{\text{LocArea}_a} + \beta X_{iat} \times \text{TIME}_t + \epsilon_{iat} \tag{2}
\]

\[
Y_{iat} = \gamma_{\text{MSAGroup}_a \times 2020} + \theta_{\text{LocArea}_a} + \beta X_{iat} \times \text{TIME}_t + \pi \text{State}_a \times \text{TIME}_t + \epsilon_{iat} \tag{3}
\]

\[
Y_{iat} = \gamma_{\text{MSAGroup}_a \times 2020} + \theta_{\text{LocArea}_a} + \beta X_{iat} \times \text{TIME}_t + \pi \text{State}_a \times \text{TIME}_t + \delta Z_a \times 2020 + \epsilon_{iat} \tag{4}
\]

The full regression sample includes April–October 2019–2020, but we split these months into spring (April–May), summer (June–August), and fall (September–October) sub-samples to examine evolving impacts over time. The dependent variable, \(Y_{iat}\), is a binary employment status indicator for individual \(i\) living in local area \(a\) and observed in time period \(t\). To facilitate comparison with the aggregate employment rate, we code the dependent variable as either zero or 100 instead of zero or one. Each local area is either an individually identifiable metropolitan area or a state-specific non-metropolitan residual. \(\text{MSAGroup}_a\) is a set of indicators for six MSA size groups listed in the data section. Non-metropolitan areas are the omitted reference group. 2020, is an indicator equal to one for 2020, the COVID-19 treatment period; it equals zero for 2019. \(\text{MSAGroup}_a \times 2020\) is a set of interaction variables representing MSA group specific indicators for the COVID-19 treatment period. \(\text{Local Area}_a\) is a set of indicator
variables for each local area. $X_{it} \times TIME_i$ is a set of individual characteristics interacted with a full set of time (month-year) dummies. $State_a \times TIME_i$ is a set of dummies for interactions of state and time. $Z_{it} \times 2020$ is a set of local area characteristic variables interacted with the indicator for the treatment period. $\epsilon_{it}$ is a mean zero error term. We cluster standard errors by local area.

We are estimating DD models because we are taking differences across years and across local areas relative to non-metropolitan areas. Equation (1) is equivalent to computing simple year-over-year differences for each local area and then estimating weighted regressions of these differences on MSA group indicators with weights equal to the sum of individual weights by local area. Thus, we are comparing how the COVID-19 employment impact differs between each MSA size group and non-metropolitan areas. Equation (1) is similar to year-over-year changes in Section 2.2, but we are now estimating the effects jointly over 2–3 adjacent months (April–May, June–August, and September–October) and relative to the effect for non-MSAs.4

Equation (2) modifies Equation (1) by adding detailed control variables for individual characteristics interacted with time. These interactions are collinear with the 2020, variable from Equation (1), so it is excluded from Equation (2). The individual characteristics include dummy variables for single year of age, sex, race, ethnicity, education, marital status, and presence of children in the household. Equation (2) helps assess the extent to which differences in COVID-19 impacts across MSA status and size are explained by individual characteristics.

Equation (3) extends Equation (2) by adding state × time effects to account for state policy changes and other state × time specific unobserved factors. Our analysis does not directly include state policy variables measuring restrictions on economic activity and individual mobility during the pandemic. The policies are numerous, overlapping, inconsistently enforced, difficult to accurately measure, and driven by other factors (e.g., infections and politics) including some that are difficult to measure (e.g., leadership) making causal inference difficult (Goodman-Bacon & Marcus, 2020). Monthly CPS data are also not ideal for directly analyzing policies that change by day and week. Thus, instead of trying to directly measure the impact of state policies, we take a less parametric approach and absorb the effects of state policies via state × time effects. Thus, identifying variation comes from differences across local areas within a state in a given month-year.

Equation (4) further adds explanatory variables for local area characteristics interacted with the 2020, indicator. The local area characteristics include the log of the COVID-19 infection rate, the percentage of occupations that could be done from home, and the industrial structure variables discussed above. Equation (4) is useful for assessing the extent to which differences across MSA status and size are due to these local area characteristics. Our DD regression approach for Equation (4) is similar to estimating year-over-year changes for each local area and then estimating a weighted regression of these changes on MSA size indicators and local area characteristics. The main difference is that our DD approach is done via a single regression and includes individual controls.

We expect the local infection rate to have a significant adverse effect on employment due to efforts to reduce spread and exposure (Chetty et al., 2020). Furthermore, early vulnerability to the virus may have persistent effects several months later. Therefore, we include two measures of the COVID-19 infection rate in local areas, the infection rate in the (current) survey month and the infection rate in March 2020. March 2020 is the first month that the virus became widespread in the U.S. We expect both COVID-19 measures to have negative effects on local employment. A higher percentage of occupations that can be done from home is expected to produce better employment outcomes during the pandemic (Dingel & Neiman, 2020). We expect prior employment concentration in leisure and hospitality to have a negative effect on employment outcomes during the COVID-19 treatment period. We also expect areas with more employment in transportation and utilities and public administration to have better employment outcomes during April–May 2020. Expectations for the other industry variables are more ambiguous.
4 | EMPIRICAL RESULTS

Table 3 presents DD regression results for changes in employed at work in April–May 2020 relative to April–May 2019 for MSA population size groups relative to non-MSAs. Columns (1)–(3) present results for Equations (1)–(3). Columns (4)–(6) present variants of Equation (4). The varying specifications help assess the importance of individual and local characteristics for the differing impacts of COVID-19 on employed at work rates across MSA status and size.

Column (1) of Table 3 excludes individual and local characteristic variables. The 2020 indicator variable measures the effect of COVID-19 for non-MSAs and the interactions of MSA size indicators with 2020 measure effects of COVID-19 relative to non-MSAs. The coefficient estimate for 2020 indicates that COVID-19 decreased the average employed at work rate in non-metropolitan areas in April–May 2020 by 7.8% points relative to April–May 2019, a very similar estimate as the average of April and May year-over-year changes in Table 2 (−7.9). The coefficient estimates for interactions of 2020 with MSA size dummies in Column (1) are negative and statistically significant for the three largest population groups. The coefficient for the largest MSA group implies that COVID-19 decreased

| MSA Pop. 100–250 K × 2020 | (1) | (2) | (3) | (4) | (5) | (6) |
|---------------------------|-----|-----|-----|-----|-----|-----|
| −1.523                    | (1.153) | −1.072 | (1.028) | 0.784 | (1.028) | 0.733 | (1.029) | 0.691 | (1.045) |

| MSA Pop. 250–500 K × 2020 | −2.849** | (0.962) | −1.649 | (0.857) | −0.830 | (0.915) | 1.446 | (1.046) | 1.368 | (1.051) | 1.271 | (1.067) |

| MSA Pop. 500 K–1 M × 2020 | −1.691 | (0.969) | −1.230 | (0.882) | −0.831 | (0.862) | 1.797 | (1.111) | 1.726 | (1.110) | 1.361 | (1.120) |

| MSA Pop. 1–2.5 M × 2020 | −3.547** | (1.059) | −3.376** | (0.956) | −2.797** | (0.884) | 0.954 | (1.313) | 0.876 | (1.309) | 0.270 | (1.303) |

| MSA Pop. 2.5–5 M × 2020 | −4.150** | (1.549) | −4.062** | (1.539) | −3.404** | (1.221) | 0.771 | (1.563) | 0.576 | (1.524) | 0.132 | (1.611) |

| MSA Pop. 5 M+ × 2020 | −5.298** | (1.165) | −5.093** | (1.111) | −4.885** | (1.006) | 0.478 | (1.692) | 0.171 | (1.634) | −0.549 | (1.698) |

| Year 2020 Dummy | −7.796** | (0.630) |

| Ln COVID Case Rate March 2020 × 2020 | −1.116* | (0.436) | −1.257** | (0.450) |

| Ln COVID Case Rate Current × 2020 | −0.339 | (0.304) | −0.666* | (0.327) |

| % Occ. Can Work from Home × 2020 | 0.111 | (0.108) | 0.122 | (0.109) | 0.111 | (0.107) |

| % Employed in Agriculture × 2020 | 0.328* | (0.134) | 0.336* | (0.134) | 0.281* | (0.138) |

| % Employed in Mining × 2020 | 0.126 | (0.230) | 0.150 | (0.234) | 0.115 | (0.234) |

(Continues)
CHO et al. employed at work by 5.3% points more in MSAs with population 5 M+ than in non-MSAs, an estimate that is also very similar to that implied by April and May year-over-year changes in Table 2.

Column (2) of Table 3 includes controls for interactions of individual characteristics and time dummies; time refers to unique combinations of month and year. Coefficient estimates in Column (2) are again negative and statistically significant for the three largest MSA population groups and the coefficient estimate magnitudes in Column (2) are similar to Column (1). Thus, differences in individual characteristics appear to explain a minimal portion of the differences in COVID-19 employment impacts between non-MSAs and large MSAs in April and May 2020. Column (3) adds state × time effects. The coefficient estimates for the three largest MSA groups are still negative, statistically significant, and comparable in magnitude to Column (1). State × time effects also appear to explain very little of the greater employment losses in large MSAs in April and May 2020.

Column (4) includes all local area characteristic variables including both COVID-19 infection variables. Columns (5) and (6) present sensitivity analysis regressions that each include only one of

| % Employed in Construction × 2020 | −0.048 | −0.027 | −0.108 |
|----------------------------------|--------|--------|--------|
|                                  | (0.187)| (0.185)| (0.188)|
| % Emp. Wholesale/Retail × 2020   | 0.021  | 0.041  | 0.056  |
|                                  | (0.163)| (0.164)| (0.165)|
| % Emp. Transportation/Utilities × 2020 | 0.240 | 0.227 | 0.183 |
|                                  | (0.167)| (0.169)| (0.172)|
| % Emp. Professional Services × 2020 | −0.138 | −0.130 | −0.205 |
|                                  | (0.145)| (0.145)| (0.148)|
| % Emp. Education/Health × 2020   | 0.171  | 0.183* | 0.115  |
|                                  | (0.087)| (0.087)| (0.091)|
| % Emp. Leisure/Hospitality × 2020 | −0.424** | −0.410** | −0.446** |
|                                  | (0.141)| (0.142)| (0.146)|
| % Employed in Other Services × 2020 | −0.053 | −0.068 | −0.040 |
|                                  | (0.333)| (0.332)| (0.335)|
| % Emp. Public Administration × 2020 | 0.098  | 0.092  | 0.116  |
|                                  | (0.130)| (0.130)| (0.132)|
| Local Area Fixed Effects | Yes | Yes | Yes | Yes | Yes |
| Indiv. Characteristics × Time Dummies | No | Yes | Yes | Yes | Yes |
| State × Time Dummies | No | No | Yes | Yes | Yes |
| F-Test p-Value for Industry Variables | < 0.0001 | < 0.0001 | 0.0001 |
| R² | 0.025 | 0.280 | 0.281 | 0.281 | 0.281 |
| Observations | 327,795 | 327,795 | 327,795 | 327,795 | 327,795 |

Note: The sample includes civilians aged 16 and over. Standard errors in parentheses are clustered by local area. Local areas include individual MSAs and state-specific non-MSA residual areas. Non-MSAs are the excluded MSA status/size group. Time refers to unique combinations of month and year.

*Significantly different from zero at 5% level; **Significant at 1% level.
the COVID-19 infection rate variables along with all the other variables. Column (4) is the preferred specification for Equation (4), but the persistence in COVID-19 infection rates over time encourages examination of the alternative specifications. Adding the local characteristic variables substantially alters the coefficient estimates for MSA size interactions with 2020. The MSA size interactions are now all not statistically significant. In particular, the coefficient estimate for MSAs with population 5 M+ changes from −5.3 in Column (1) to 0.5 in Column (4) indicating that the variables in Column (4) essentially fully explain the differing employment impact of COVID-19 between non-MSAs and MSAs with population 5 M+ in April–May 2020.

The March 2020 COVID-19 infection rate variable has a large and statistically significant negative effect on employment in both Columns (4) and (5). The current infection rate variable has a significant negative coefficient in Column (6) but is not significant in Column (4). The COVID-19 infection rate in March 2020 is correlated with infection rates in April 2020 and May 2020, which reduces the coefficient and significance level for the latter variable when both variables are included simultaneously. Column (4) is the preferred specification. One way to assess relative magnitudes is to combine the coefficient estimates with differences in explanatory variable means across sub-samples in Table 1. Multiplying the March infection variable coefficient (−1.116) from Column (4) by the difference in Table 1 means between non-MSAs and the largest MSA group (1.77) implies that the higher infection rate in March 2020 in MSAs with population 5 M+ explains a 1.98% point greater employment decline in the largest MSA group. Thus, COVID-19 infection rates explain a considerable portion of the overall differential impacts between non-MSAs and the largest MSA group. We will provide additional context for the infection variable magnitudes later.

The work from home variable coefficient is not statistically significant. However, we include detailed individual controls and additional industry controls. Ability to work from home certainly matters for individuals, but the MSA percentage is not significant in our models. Only two of the industrial structure variables are statistically significant at the 5% level in Column (4). The percentage employed in agriculture has a significant positive coefficient, suggesting that agricultural employment partially insulated local areas from overall job losses early in the pandemic. To help assess the overall importance of agricultural employment in differential early employment losses between non-MSAs and the very largest MSAs (5 M+), we multiply the 0.328 agricultural employment coefficient in Column (4) by the difference in means between the two groups in Table 1 (−5.68) to suggest that agricultural employment explains 1.86% points of the 5.3% point differential for the largest MSA group in Column (1). Thus, agricultural employment appears to be an important factor stabilizing local employment early in the pandemic. The percentage employed in leisure and hospitality has a negative coefficient in all three columns as expected. The means for this variable do not differ systematically across MSA size in Table 1, but the mean is moderately lower in non-MSAs. Specifically, the leisure and hospitality employment share is 1.23% points lower in non-MSAs than in the largest MSA group. Multiplying the −0.424 coefficient by this difference in means indicates that leisure and hospitality employment explains a 0.52% point difference between non-MSAs and MSAs. Compared to the 5.3% point coefficient for the largest MSA group in Column (1), the contribution of differential leisure and hospitality employment is non-trivial but not a predominant factor.

Table 4 presents regression results for changes in employed at work rates in June–August 2020 relative to June–August 2019. The Table is structured similarly to Table 3. There are again large differences across MSA status and population size groups in Column (1). Adding individual controls and state × time effects in Columns (2) and (3) minimally reduces the MSA group coefficient estimate magnitudes, but the coefficient estimates are consistently negative and statistically significant for the five largest MSA groups. The coefficient for MSAs with population 5 M+ goes from −4.9 in Column (1) to −4.3 in Column (3), indicating that there are still large differences even after accounting for
these initial control variables. Adding local area characteristic variables in Columns (4)–(6) reduces coefficient estimates for the MSA size group interaction dummies, but the changes are not as large as in Table 3 and some remain negative and statistically significant. Furthermore, none of the additional local area characteristic variables in the last three columns are statistically significant at the 5% level except for the leisure and hospitality employment share. Of some note, the March 2020 infection variable has a coefficient estimate of $-0.61$ in Column (4), which is not statistically significant ($p$-value $= .129$) but does weakly suggest a moderately important influence.

**TABLE 4** June–August 2019–2020 employed at work regression results

|                        | (1)     | (2)     | (3)     | (4)     | (5)     | (6)     |
|------------------------|---------|---------|---------|---------|---------|---------|
| MSA Pop. 100–250 K × 2020 | $-0.797$ | $-0.597$ | $-0.672$ | $-0.305$ | $-0.310$ | $-0.386$ |
|                        | (1.009) | (0.836) | (0.811) | (0.907) | (0.900) | (0.929) |
| MSA Pop. 250–500 K × 2020 | $-4.239^*$ | $-3.205^*$ | $-3.109^*$ | $-2.392^*$ | $-2.403^*$ | $-2.532^*$ |
|                        | (0.992) | (0.903) | (0.867) | (0.960) | (0.944) | (0.979) |
| MSA Pop. 500 K–1 M × 2020 | $-2.359^*$ | $-1.828^*$ | $-1.315^*$ | $-0.669$ | $-0.684$ | $-0.959$ |
|                        | (0.770) | (0.660) | (0.647) | (0.848) | (0.824) | (0.867) |
| MSA Pop. 1–2.5 M × 2020 | $-4.127^*$ | $-3.994^*$ | $-3.974^*$ | $-2.399^*$ | $-2.417^*$ | $-2.849^*$ |
|                        | (0.821) | (0.641) | (0.576) | (0.965) | (0.957) | (0.990) |
| MSA Pop. 2.5–5 M × 2020 | $-4.838^*$ | $-4.347^*$ | $-3.363^*$ | $-2.058$ | $-2.077$ | $-2.559^*$ |
|                        | (0.948) | (0.796) | (0.810) | (1.163) | (1.128) | (1.205) |
| MSA Pop. 5 M+ × 2020   | $-4.919^*$ | $-4.573^*$ | $-4.305^*$ | $-2.229$ | $-2.252$ | $-3.032^*$ |
|                        | (0.907) | (0.802) | (0.682) | (1.252) | (1.190) | (1.245) |
| Year 2020 Dummy        | $-2.008^*$ |          |          |          |          |          |
|                        |         |         |         | (0.539) |         |          |
| Ln COVID Case Rate     |          | $-0.613$ | $-0.613$ |          |          |          |
| March 2020 × 2020      |          | (0.403) | (0.402) |          |          |          |
| Ln COVID Case Rate     |          | $-0.026$ |          | $-0.052$ |          |          |
| Current × 2020         |          | (0.402) |          | (0.399) |          |          |
| % Occ. Can Work from Home × 2020 | $-0.047$ | $-0.046$ | $-0.043$ |          |          |          |
|                        | (0.093) | (0.093) | (0.093) |          |          |          |
| % Employed in          |          |          |          | $-0.128$ | $-0.129$ | $-0.153$ |
| Agriculture × 2020     |          |          |          | (0.102) | (0.102) | (0.100) |
| % Employed in          |          |          |          | $-0.118$ | $-0.118$ | $-0.109$ |
| Mining × 2020          |          |          |          | (0.148) | (0.149) | (0.154) |
| % Employed in          |          |          |          | $-0.080$ | $-0.079$ | $-0.106$ |
| Construction × 2020    |          |          |          | (0.166) | (0.166) | (0.167) |
| % Emp. Wholesale/Retail | 0.037   | 0.037   | 0.070   |          |          |          |
| × 2020                 | (0.167) | (0.168) | (0.166) |          |          |          |
| % Emp. Transportation/Utilities × 2020 | $-0.187$ | $-0.188$ | $-0.228$ |          |          |          |
|                        | (0.140) | (0.140) | (0.138) |          |          |          |

(Continues)
Table 5 presents employed at work regression results for September–October 2020 relative to September–October 2019. The MSA group interaction dummies for the two largest MSA groups are significant in Column (1), but the magnitudes are somewhat smaller than in Column (1) of Tables 3 and 4. Adding individual controls in Column (2) and state × time effects in Column (3) also alters the MSA group coefficient estimates somewhat more than before. The coefficient estimate for MSAs with population 5 M+ goes from −3.6 in Column (1) to −2.3 in Column (3). Adding the additional local area characteristics in Column (4) reduces the large MSA group coefficient estimates further, and none of the MSA group coefficients are significant in Column (4). In Column (4) both COVID-19 infection variables have negative and statistically significant coefficients. The March infection variable loses significance in Column 5 but is still marginally significant (p-value = .066). Again, Column (4) is the preferred specification. Among the other local characteristic variables, only the mining employment share variable is statistically significant; it has a coefficient of −0.377 in Column (4).

The results in Tables 3–5 indicate a nuanced story for the role of local infection rates in explaining differential employment impacts across MSA status and size. To help summarize the relationships, we present Table 6 which combines the COVID-19 infection variable coefficients (from Column 4 of Tables 3–5) with the differences in Table 1 infection variable means between non-MSAs and the 5 M+ MSA group. Column (1) of Table 6 summarizes impacts for April–May. As indicated above, multiplying the March infection variable coefficient by the difference in sub-sample means explains a 1.983% point greater employment decline in the 5 M+ population MSA group relative to non-MSAs. Furthermore, multiplying the current infection variable coefficient estimate by its difference in means

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| % Emp. Professional Services × 2020 | −0.036 | −0.036 | −0.071 |
| | (0.111) | (0.111) | (0.108) |
| % Emp. Education/Health × 2020 | 0.0004 | 0.0002 | −0.027 |
| | (0.077) | (0.077) | (0.074) |
| % Emp. Leisure/Hospitality × 2020 | −0.368* | −0.367* | −0.374* |
| | (0.180) | (0.179) | (0.175) |
| % Employed in Other Services × 2020 | 0.066 | 0.067 | 0.065 |
| | (0.288) | (0.288) | (0.287) |
| % Emp. Public Administration × 2020 | 0.109 | 0.108 | 0.117 |
| | (0.101) | (0.101) | (0.099) |
| Local Area Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Indiv. Characteristics × Time Dummies | No | Yes | Yes | Yes | Yes | Yes |
| State × Time Dummies | No | No | Yes | Yes | Yes | Yes |
| F-Test p-Value for Industry Variables | 0.664 | 0.662 | 0.467 |
| R² | 0.014 | 0.251 | 0.252 | 0.252 | 0.252 | 0.252 |
| Observations | 482,332 | 482,332 | 482,332 | 482,332 | 482,332 | 482,332 |

Note: The sample includes civilians aged 16 and over. Standard errors in parentheses are clustered by local area. Local areas include individual MSAs and state-specific non-MSA residual areas. Non-MSAs are the excluded MSA status/size group. Time refers to unique combinations of month and year.

*Significantly different from zero at 5% level; **Significant at 1% level.
|                           | (1)       | (2)       | (3)       | (4)       | (5)       | (6)       |
|---------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| MSA Pop. 100–250 K × 2020 | −0.769    | −0.751    | −0.807    | −1.496    | −1.444    | −1.602    |
|                           | (1.143)   | (0.865)   | (0.859)   | (0.951)   | (0.948)   | (0.975)   |
| MSA Pop. 250–500 K × 2020 | −2.697**  | −1.595    | −1.465    | −1.741    | −1.938*   | −1.948    |
|                           | (0.907)   | (0.838)   | (0.823)   | (0.962)   | (0.964)   | (1.001)   |
| MSA Pop. 500 K–1 M × 2020 | −1.629    | −1.044    | −0.649    | −1.085    | −1.128    | −1.486    |
|                           | (0.878)   | (0.759)   | (0.764)   | (0.967)   | (0.975)   | (0.992)   |
| MSA Pop. 1–2.5 M × 2020  | −1.652    | −1.647*   | −1.550*   | −1.454    | −1.526    | −2.062    |
|                           | (0.925)   | (0.769)   | (0.781)   | (1.152)   | (1.161)   | (1.171)   |
| MSA Pop. 2.5–5 M × 2020  | −3.323**  | −2.852**  | −1.319    | −1.171    | −1.307    | −1.861    |
|                           | (0.898)   | (0.743)   | (0.836)   | (1.181)   | (1.192)   | (1.252)   |
| MSA Pop. 5 M+ × 2020     | −3.630**  | −2.952**  | −2.292**  | −1.380    | −1.725    | −2.489    |
|                           | (0.795)   | (0.880)   | (0.782)   | (1.308)   | (1.340)   | (1.345)   |
| Year 2020 Dummy           | −2.123**  |           |           |           |           |           |
|                           | (0.647)   |           |           |           |           |           |

| Ln COVID Case Rate March 2020 × 2020 | −0.808* | −0.717 |
|                                     | (0.378) | (0.388) |

| Ln COVID Case Rate Current × 2020 | −1.317* | −1.190* |
|                                    | (0.535) | (0.542) |

| % Occ. Can Work from Home × 2020 | 0.056   | 0.064   | 0.062   |
|                                   | (0.091) | (0.091) | (0.093) |

| % Employed in Agriculture × 2020 | −0.093  | −0.101  | −0.126  |
|                                  | (0.130) | (0.129) | (0.129) |

| % Employed in Mining × 2020      | −0.377* | −0.344* | −0.361* |
|                                  | (0.159) | (0.160) | (0.166) |

| % Employed in Construction × 2020 | 0.020   | 0.048   | −0.012  |
|                                   | (0.176) | (0.175) | (0.178) |

| % Emp. Wholesale/Retail × 2020   | 0.162   | 0.166   | 0.207   |
|                                  | (0.138) | (0.138) | (0.140) |

| % Emp. Transportation/Utilities × 2020 | −0.073  | −0.103  | −0.131  |
|                                        | (0.135) | (0.136) | (0.128) |

| % Emp. Professional Services × 2020 | −0.067  | −0.056  | −0.112  |
|                                     | (0.119) | (0.120) | (0.119) |

| % Emp. Education/Health × 2020    | 0.067   | 0.049   | 0.030   |
|                                    | (0.079) | (0.080) | (0.079) |

| % Emp. Leisure/ Hospitality × 2020 | −0.119  | −0.088  | −0.125  |
|                                     | (0.136) | (0.135) | (0.134) |

| % Employed in Other Services × 2020 | 0.260   | 0.256   | 0.261   |
|                                     | (0.310) | (0.314) | (0.311) |
yields −0.402% points. Thus, the combined effect of the two local area infection rate variables in April–May 2020 is −2.385% points. We can also divide this by the Column (1) coefficient for MSAs with population 5 M+ (−5.298) to find that the two COVID-19 infection variables combine to explain 45.0% of the greater employment reduction in very large MSAs in April–May 2020. In other words, the local infection rate was a critically important contributing factor for the higher rate of job loss in very large MSAs during the early months of the pandemic.

Columns (2) and (3) of Table 6 replicate this exercise for June–August and September–October, respectively. Though the March infection variable coefficient is not statistically significant for June–August, the point estimate suggests that the variable explains a sizable chunk of differential employment reductions; contemporaneous infection rates explain very little during this period. The combined
effect in Column (2) is $-1.096\%$ points, which accounts for $22.3\%$ of the larger employment decrease for very large MSAs during this period.

In Column (3) of Table 6, the infection variables partially offset during September–October. Both have negative effects on employment, but the pattern across MSA status and size in Table 1 sample means differs. Specifically, while the March 2020 infection rate mean increased with MSA status and population size, the September and October 2020 infection means exhibited the opposite pattern. The infection rate was highest in non-MSAs during these latter two months. Multiplying the March infection variable coefficient by the difference in means explains a $1.436\%$ point lower employment at work rate for very large MSAs. However, multiplying the current infection variable coefficient by the corresponding difference in means implies a $0.619\%$ point higher employment at work rate for very large MSAs relative to non-MSAs. The combined effect is $-0.817\%$ points, which corresponds to $22.5\%$ of the differential employment decrease for very large MSAs during this period. Thus, although the two infection variables have opposite direction effects in explaining differences between non-MSAs and MSAs with population $5\ M+$ in September–October 2020, the greater difference in means for the March 2020 infection variable dominates the contemporaneous effect. In other words, despite the greater contemporaneous infection rates in non-MSAs in September–October, the lagged effect has greater relative importance for explaining employment differences between non-MSAs and very large MSAs.

The appendix presents additional results for alternative specifications. Appendix Tables A4–A6 split the full sample into individuals with no college education and those with at least some college. Given space limitations, we focus on the minimum controls specification (Column 1 in Tables 3–5) and the full controls specification (Column 4 in Tables 3–5). Columns (1) and (2) of Appendix Tables A4–A6 report results for the minimum controls specification for the two education groups. Columns (4) and (5) of Appendix Tables A4–A6 report results for the full controls specification. Columns (3) and (6) report the differences in coefficients between the two education groups with standard errors estimated via pooled sample regression with a full set of interaction terms between a no college dummy and all other explanatory variables. The results are largely similar for low and high education workers during the early months of the pandemic. However, for the September-October results in Appendix Table A6, the medium and large MSA variables have more negative coefficients for less educated (Column 4) than more educated workers (Column 5). While not definitive, this may suggest that less educated workers in these MSAs experienced more persistent job losses than both similarly educated workers in non-MSAs and similarly located workers with more education, even after accounting for the other explanatory variables in the model.

Appendix Tables A7–A9 report results that use broader MSA population size groups. Instead of the six MSA population size groups used in the main analysis, these tables combine MSAs into only two groups, those with population less than one million (MSA Pop. $<1\ M$) and those with population greater than one million (MSA Pop. $1\ M+$). Non-MSAs are again the omitted reference group. The coefficients for the MSA Pop. $<1\ M$ and MSA Pop. $1\ M+$ variables are roughly equal to sample weighted averages of the corresponding more detailed MSA variable coefficients in the main analysis. Furthermore, the coefficients for the other variables in Appendix Tables A7–A9 are very similar to corresponding coefficients in Tables 3–5. Thus, these appendix results are qualitatively similar to the main results.

5 | CONCLUSION

COVID-19 severely disrupted labor markets in areas big and small. However, employment rate decreases in the United States were most severe in larger MSAs and this pattern persisted from April to October 2020. Employed at work rates decreased by $9.6\%$ points in non-metropolitan areas but by $14.6\%$ points in MSAs with populations greater than five million in April 2020 relative to April 2019.
Non-MSAs and all MSA population size groups partially recovered in subsequent months but had not fully recovered by October 2020. Employment rates in October 2020 were still 5.0% points lower than in October 2019 for the largest MSA population group. For non-MSAs the October year-over-year decrease was only 2.0% points.

We also examine the influence of individual and local area characteristics. Controlling for the full set of individual characteristics and state × time effects to account for state policies only moderately explains the differing employment changes between non-MSAs and MSAs with populations greater than five million. COVID-19 infection rates initially hit large MSAs hardest, and we find this is an important factor for labor market differences. The effect of the virus on local employment was largely due to individuals and firms altering their behaviors to reduce their own exposure to the virus (Chetty et al., 2020). Fear and uncertainty were powerful disruptors to economic activity (Goolsbee & Syverson, 2021). Local infection rates explain 45% of the differing employment changes between non-MSAs and the largest MSAs in April–May 2020 and about 22% in later months. Notably, infection rates in September and October 2020 were highest in non-MSAs, opposite of the initial pattern. Higher contemporaneous infection rates in September and October 2020 reduced local employment rates, but the early COVID-19 infection rates also had persistent negative effects. The persistent influence of early infection rates outweighed contemporaneous effects and contributed to larger year-over-year employment reductions in very large MSAs through September and October 2020. The persistent effects may reflect some combination of reduced labor demand, reduced labor supply, and labor market frictions that prevent quick employer-employee re-matching during the economic recovery (Hall & Kudlyak, 2021).

COVID-19 has had devastating effects on health, productivity, and well-being. Large metropolitan areas were especially affected during the early months of COVID-19. Medium and long run impacts of COVID-19 on cities and regions are less clear but likely important. To some extent, the greater COVID-19 severity in large metropolitan areas may increase the speed of vaccinations, which can help them recovery economically. Increased working from home appears likely to persist partially even well after the current pandemic subsides. This will likely reduce demand for big city commercial space and increase demand for residential space in smaller and medium population cities, big city suburbs, and rural areas. National populations may become less concentrated in large cities, and tax base erosion may be especially problematic for some big cities. Other places may boom as the national landscape is reshaped by COVID-19. Workers and entrepreneurs may increasingly move toward areas with more affordable housing and good high-speed internet. Production and trade may further evolve to become more resilient to future viruses.

**CONFLICT OF INTEREST**
The authors have declared no conflicts of interest for this article.

**DATA AVAILABILITY STATEMENT**
The primary data analyzed in this study are publicly available. The authors will share code and processed data with interested researchers.

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**ENDNOTES**
1 The term “at work” includes persons who telecommute.

2 October 2020 was the most recent available CPS data at the time of our analysis.
3 The survey reference week for January through October is the calendar week beginning on a Sunday that includes the 12th of the month. The survey reference week can occur earlier in November and December to avoid overlap with major holidays.

4 The two approaches also differ in how weights are applied, but these are very similar calculations and produce very similar results.

5 In results not shown, we also examined including subsets of individual controls. Age, gender, marital status, and presence of children explain little of the differences between non-MSAs and the two largest MSA groups. However, controlling only for race and ethnicity decreases the coefficient estimates for large MSAs while controlling only for education increases these coefficient estimates. The net effect is that controlling for the full set of individual characteristics explains virtually none of the difference between non-MSAs and the two largest MSA groups.

6 We also tested for multicollinearity using the R package fixest. The test results indicate that the full specification (Column 4) does not have a multicollinearity problem in any period.

7 Because agricultural and mining employment are so concentrated in non-metropolitan areas, we were somewhat concerned that these variables might be correlated with omitted variables related to differences between non-MSAs and large MSAs. Thus, we report results in Appendix Table A3 similar to Column (4) of Tables 3–5 except local area employment percentage controls for agriculture and mining are now excluded; this means the omitted industry group includes manufacturing, agriculture, and mining. The results in Table A3 are qualitatively similar to the main specification results.

8 The coefficient for the percentage of employment in education and health is significant at the five percent level in Column (4) but not in Columns (4) or (6). The industry variables are jointly significant in all three columns as indicated by the $F$-statistic $p$-values near the bottom of Table 3.

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### APPENDIX

#### TABLE A1  Year-over-year changes by MSA status and size for ages 25–61

|                  | (1) | (2)         | (3)         | (4)         | (5)         | (6)         | (7)         |
|------------------|-----|-------------|-------------|-------------|-------------|-------------|-------------|
|                  | Non-metro | MSA Pop. 100−250 K | MSA Pop. 250−500 K | MSA Pop. 500 K−1 M | MSA Pop. 1−2.5 M | MSA Pop. 2.5−5 M | MSA Pop. 5 M+ |
| **A. Unemployment rate** | | | | | | | |
| Jan. 2020–Jan. 19 | 0.034 | −0.817 | 0.311 | −0.668 | −0.492 | −0.422 | −0.072 |
| Feb. 2020–Feb. 19 | 0.537 | −0.261 | 0.560 | −0.251 | −0.508 | −0.642 | 0.183 |
| Mar. 2020–Mar. 19 | −0.074 | 0.051 | −0.607 | 0.296 | 0.638 | 0.396 | 1.259** |
| Apr. 2020–Apr. 19 | 8.597** | 7.814** | 9.471** | 9.161** | 10.306** | 10.188** | 11.123** |
| May 2020–May 19 | 6.417** | 6.142** | 7.845** | 7.422** | 8.568** | 9.342** | 10.382** |
| June 2020–June 19 | 3.685** | 4.937** | 6.920** | 4.894** | 6.115** | 8.058** | 8.886** |
| July 2020–July 19 | 2.830** | 3.135** | 5.804** | 4.983** | 5.767** | 6.283** | 8.546** |
| Aug. 2020–Aug. 19 | 1.923** | 1.462** | 3.875** | 3.825** | 5.268** | 4.497** | 6.037** |
| Sep. 2020–Sep. 19 | 2.285** | 1.724** | 4.084** | 3.025** | 4.122** | 4.598** | 5.723** |
| Oct. 2020–Oct. 19 | 0.999† | 2.289** | 3.132** | 2.777** | 3.513** | 2.965** | 4.618** |
| **B. Labor force participation rate** | | | | | | | |
| Jan. 2020–Jan. 19 | 0.751 | −1.293 | −0.762 | 0.378 | 0.392 | 0.699 | 0.846 |
| Feb. 2020–Feb. 19 | 0.808 | −0.209 | −0.092 | 0.867 | −0.279 | −0.143 | 0.747 |
| Mar. 2020–Mar. 19 | 0.035 | −0.546 | 0.157 | 0.280 | 0.933 | −0.614 | 0.014 |
| Apr. 2020–Apr. 19 | −1.388 | −1.882 | −0.262 | −0.533 | −1.866** | −3.336** | −3.563** |
| May 2020–May 19 | −0.032 | 0.355 | −1.432 | 0.439 | −1.258 | −3.223** | −2.822** |
| June 2020–June 19 | 0.476 | 0.170 | −0.611 | 1.003 | −0.816 | −1.716† | −1.288† |
| July 2020–July 19 | 0.775 | 1.652 | −0.790 | −0.667 | −2.029** | −1.331 | −0.166 |
| Aug. 2020–Aug. 19 | 0.370 | −0.498 | −1.136 | −1.411 | −1.696† | −1.220 | −0.985 |
| Sep. 2020–Sep. 19 | −0.946 | −0.406 | −2.468† | −1.146 | −2.393** | −1.901** | −1.703** |
| Oct. 2020–Oct. 19 | −1.408 | −1.598 | −2.059† | −0.705 | −1.746** | −1.208 | −1.389† |

(Continues)
|                | (1) Non-metro | (2) MSA Pop. 100−250 K | (3) MSA Pop. 250−500 K | (4) MSA Pop. 500 K−1 M | (5) MSA Pop. 1−2.5 M | (6) MSA Pop. 2.5−5 M | (7) MSA Pop. 5 M+ |
|----------------|---------------|------------------------|------------------------|------------------------|----------------------|----------------------|------------------|
| **C. Employment-to-population ratio** |               |                        |                        |                        |                      |                      |                  |
| Jan. 2020–Jan. 2019 | 0.694         | −0.604                 | −0.977                 | 0.897                  | 0.780                | 1.027                | 0.878            |
| Feb. 2020–Feb. 2019 | 0.363         | 0.003                  | 0.358                  | 1.038                  | 0.146                | 0.388                | 0.574            |
| Mar. 2020–Mar. 2019 | 0.089         | −0.566                 | 0.633                  | 0.034                  | 0.382                | −0.918               | −1.015           |
| Apr. 2020–Apr. 2019 | −7.784**      | −7.836**               | −7.684**               | −7.705**               | −9.985**             | −11.307**            | −12.085**        |
| May 2020–May 2019   | −4.931**      | −4.473**               | −7.510**               | −5.461**               | −8.054**             | −10.536**            | −10.857**        |
| June 2020–June 2019 | −2.354**      | −3.698**               | −6.026**               | −2.923**               | −5.684**             | −8.157**             | −8.320**         |
| July 2020–July 2019 | −1.428        | −0.901                 | −5.297**               | −4.536**               | −6.573**             | −6.356**             | −6.993**         |
| Aug. 2020–Aug. 2019 | −1.109        | −1.624                 | −4.140**               | −4.342**               | −5.863**             | −4.823**             | −5.803**         |
| Sep. 2020–Sep. 2019 | −2.647**      | −1.741                 | −5.542**               | −3.495**               | −5.608**             | −5.570**             | −6.250**         |
| Oct. 2020–Oct. 2019 | −2.116**      | −3.308**               | −4.458**               | −2.860**               | −4.524**             | −3.608**             | −5.073**         |
| **D. Has job not at work rate** |               |                        |                        |                        |                      |                      |                  |
| Jan. 2020–Jan. 2019 | −0.437        | 0.021                  | −0.425                 | −0.270                 | 0.026                | −0.347               | −0.359           |
| Feb. 2020–Feb. 2019 | 0.047         | 0.243                  | −0.134                 | −0.061                 | 0.079                | −0.210               | −0.448*          |
| Mar. 2020–Mar. 2019 | 0.293         | 0.293                  | 0.283                  | 0.514                  | 1.039**              | 0.772*               | 0.529*           |
| Apr. 2020–Apr. 2019 | 2.524**       | 3.671**                | 4.232**                | 3.276**                | 2.682**              | 2.055**              | 5.257**          |
| May 2020–May 2019   | 1.729**       | 2.014**                | 1.377**                | 1.904**                | 1.784**              | 1.434**              | 2.362**          |
| June 2020–June 2019 | −0.076        | 0.458                  | 0.956                  | 0.102                  | 0.472                | 0.415                | 0.591*           |
| July 2020–July 2019 | 0.508         | 1.427*                 | 1.313*                 | −0.305                 | −0.138               | −0.078               | 0.076            |
| Aug. 2020–Aug. 2019 | 1.232**       | 0.500                  | 0.429                  | −0.400                 | 0.520                | 0.028                | 0.463            |
| Sep. 2020–Sep. 2019 | 0.647**       | 1.617**                | 0.598                  | 0.147                  | 0.495*               | 1.150**              | 0.321            |

(Continues)
| Non-metro | MSA Pop. 100–250 K | MSA Pop. 250–500 K | MSA Pop. 500 K–1 M | MSA Pop. 1–2.5 M | MSA Pop. 2.5–5 M | MSA Pop. 5 M+ |
|----------|---------------------|---------------------|---------------------|------------------|------------------|------------------|
| Oct. 2020–Oct. 2019 | 0.419              | 0.273               | 0.783*              | 0.691**          | 0.058            | 0.392            | 0.360           |

**E. Employed at work rate**

| Month     | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|-----------|-----|-----|-----|-----|-----|-----|-----|
| Jan. 2020-Jan. 2019 | 1.131 | −0.625 | −0.552 | 1.167 | 0.754 | 1.374 | 1.237* |
| Feb. 2020-Feb. 2019 | 0.316 | −0.240 | 0.492 | 1.099 | 0.067 | 0.598 | 1.022 |
| Mar. 2020-Mar. 2019 | −0.204 | −0.860 | 0.351 | −0.481 | −0.657 | −1.690* | −1.544* |
| Apr. 2020-Apr. 2019 | −10.308** | −11.506** | −11.917** | −10.981** | −12.667** | −13.362** | −17.342** |
| May 2020-May 2019 | −6.659** | −6.487** | −8.887** | −7.365** | −9.838** | −11.970** | −13.219** |
| June 2020-June 2019 | −2.279* | −4.156** | −6.982** | −3.025** | −6.156** | −8.573** | −8.911** |
| July 2020-July 2019 | −1.936* | −2.328 | −6.609** | −4.231** | −6.435** | −6.279** | −7.069** |
| Aug. 2020-Aug. 2019 | −2.341** | −2.123 | −4.569** | −3.942** | −6.383** | −4.851** | −6.265** |
| Sep. 2020-Sep. 2019 | −3.294** | −3.358** | −6.141** | −3.642** | −6.103** | −6.721** | −6.571** |
| Oct. 2020-Oct. 2019 | −2.535** | −3.581** | −5.241** | −3.551** | −4.582** | −4.000** | −5.433** |

**Notes:** The full sample includes civilians aged 25–61.

*Significant at 5% level; **Significant at 1% level.
|                            | (1) 2019 Pop. | (2) March 2020 Infection Rate | (3) Apr. Emp. Rate Diff. | (4) May Emp. Rate Diff. | (5) June Emp. Rate Diff. | (6) July Emp. Rate Diff. | (7) Aug. Emp. Rate Diff. | (8) Sep. Emp. Rate Diff. | (9) Oct. Emp. Rate Diff. |
|---------------------------|---------------|-------------------------------|--------------------------|-------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| New York-Newark-Jers. City, NY-NJ-PA | 19.2 M        | 0.0044%                       | −16.226**                 | −13.608**               | −10.411**                | −6.304**                 | −6.050**                 | −8.220**                 | −5.767**                 |
| Los Angeles-Long Beach-Anaheim, CA | 13.2 M        | 0.0003%                       | −15.516**                 | −14.767**               | −8.964**                 | −8.444**                 | −8.567**                 | −9.071**                 | −4.801**                 |
| Chicago-Naperville-Elgin, IL-IN-WI | 9.5 M         | 0.0006%                       | −12.992**                 | −10.651**               | −8.751**                 | −7.433**                 | −10.971**                | −6.337**                 | −4.074*                  |
| Dallas-Fort Worth-Arlington, TX | 7.6 M         | 0.0002%                       | −15.121**                 | −6.092**                | −4.582*                  | −2.051                   | −0.867                   | −3.488                   | −5.039**                 |
| Houston-The Woodlands-Sugar Land, TX | 7.1 M         | 0.0001%                       | −9.150**                  | −4.547*                 | −0.235                   | −4.973*                  | −2.135                   | −2.630                   | −4.417*                  |
| Washington-Arl.-Alex., DC-VA-MD-WV | 6.3 M         | 0.0003%                       | −13.392**                 | −8.773**                | −9.312**                 | −4.368*                  | −3.431                   | −6.530**                 | −6.395**                 |
| Miami-Fort Lauderdale-Pomp. Beach, FL | 6.2 M         | 0.0006%                       | −20.237**                 | −17.946**               | −9.918**                 | −8.891**                 | −8.575**                 | −4.896*                  | −7.056**                 |
| Philadelphia-Cam.-Wilm., PA-NJ-DE-MD | 6.1 M         | 0.0005%                       | −13.395**                 | −10.484**               | −8.404**                 | −5.801*                  | −5.083*                  | −6.128**                 | −4.752*                  |
| Atlanta-Sandy Springs-Alpharetta, GA | 6.0 M         | 0.0004%                       | −11.457**                 | −10.979**               | −7.810**                 | −7.602**                 | −6.658**                 | −5.142*                  | −2.067                   |
| Phoenix-Mesa-Chandler, AZ | 4.9 M         | 0.0002%                       | −7.686**                  | −0.870                  | −5.655*                  | −5.489*                  | −3.046                   | −4.317*                  | −3.884                   |
| Boston-Cambridge-Newton, MA-NH | 4.9 M         | 0.0010%                       | −18.409**                 | −16.093**               | −12.649**                | −7.325**                 | −5.036**                 | −3.738*                  | −6.382**                 |
| San Francisco-Oakland-Berkeley, CA | 4.7 M         | 0.0003%                       | −13.057**                 | −13.658**               | −11.718**                | −12.126**                | −8.558**                 | −9.506**                 | −1.623                   |
| Riverside-San Bernardino-Ontario, CA | 4.7 M         | 0.0001%                       | −15.211**                 | −13.038**               | −10.301**                | −6.262*                  | −9.019*                  | −5.827*                  | −5.822*                  |
| Detroit-Warren-Dearborn, MI | 4.3 M         | 0.0015%                       | −21.084**                 | −18.824**               | −12.038**                | −10.026**                | −7.149**                 | −7.740**                 | −5.471*                  |
| Seattle-Tacoma-Bellevue, WA | 4.0 M         | 0.0010%                       | −10.578**                 | −11.806**               | −4.424                   | −3.742                   | −2.068                   | −8.637*                  | −3.941                   |
| Minneapolis-St. Paul-Bloom., MN-WI | 3.6 M         | 0.0001%                       | −7.056**                  | −6.012*                 | −0.271                   | −1.141                   | −3.697                   | −1.018                   | −1.882                   |
| San Diego-Chula Vista-Carlsbad, CA | 3.3 M         | 0.0002%                       | −13.433**                 | −10.871**               | −6.881                   | −7.117*                  | −6.866*                  | −9.779**                 | −7.273**                 |
| Tampa-St. Petersburg-Clearwater, FL | 3.2 M         | 0.0002%                       | −5.496                    | −7.033*                 | −8.124**                 | −4.412                   | −6.515*                  | −4.560                   | −3.307                   |
| Denver-Aurora-Lakewood, CO | 3.0 M         | 0.0005%                       | −14.294**                 | −12.916**               | −9.891**                 | −6.014*                  | −2.803                   | −8.213**                 | −4.672                   |

(Continues)
| City                                      | 2019 Pop. | March 2020 Infection Rate | Apr. Emp. Rate Diff. | May Emp. Rate Diff. | June Emp. Rate Diff. | July Emp. Rate Diff. | Aug. Emp. Rate Diff. | Sep. Emp. Rate Diff. | Oct. Emp. Rate Diff. |
|-------------------------------------------|-----------|---------------------------|----------------------|--------------------|----------------------|----------------------|----------------------|----------------------|---------------------|
| St. Louis, MO-IL                          | 2.8 M     | 0.0003%                   | −11.420**            | −9.894**           | −5.667               | −5.493               | −4.584               | −2.347               | 0.654               |
| Baltimore-Columbia-Towsen, MD             | 2.8 M     | 0.0003%                   | −10.492**            | −12.488**          | −8.106**             | −11.810**            | −5.566               | −11.937**            | −9.904**            |
| Charlotte-Concord-Gastonia, NC-SC         | 2.6 M     | 0.0002%                   | −13.984**            | −8.355**           | −8.962**             | −8.244**             | −7.350*              | −5.456               | −3.339              |
| Orlando-Kissimmee-Sanford, FL             | 2.6 M     | 0.0003%                   | −18.430**            | −19.829**          | −14.286**            | −13.208**            | −7.988*              | −6.033               | −3.693              |
| San Antonio-New Braunfels, TX             | 2.6 M     | 0.0001%                   | −14.608**            | −10.547**          | −3.778               | 0.495                | −3.779               | −5.731               | −0.474              |
| Portland-Vancouver-Hillsboro, OR-WA       | 2.5 M     | 0.0002%                   | −8.170**             | −6.155*            | −1.446               | −0.941               | 0.076                | 2.350                | 0.084               |
| Sacramento-Roseville-Folsom, CA           | 2.4 M     | 0.0001%                   | −8.912**             | −10.563**          | −7.550*              | −4.724               | −6.389               | −6.714*              | −4.372              |
| Pittsburgh, PA                            | 2.3 M     | 0.0002%                   | −17.303**            | −11.177**          | −8.566*              | −6.304               | −14.592**            | −1.503               | 1.381               |
| Las Vegas-Henderson-Paradise, NV          | 2.3 M     | 0.0004%                   | −21.224**            | −21.573**          | −10.469**            | −9.582**             | −12.099**            | −8.292**             | −4.598              |
| Austin-Round Rock-Georgetown, TX          | 2.2 M     | 0.0001%                   | −11.163**            | −15.847**          | −14.349**            | −12.683**            | −8.821*              | −14.035**            | −4.105              |
| Cincinnati, OH-KY-IN                      | 2.2 M     | 0.0001%                   | −13.934**            | −13.103**          | −13.454**            | −10.028**            | −0.393               | −0.332               | −0.938              |
| Kansas City, MO-KS                        | 2.2 M     | 0.0002%                   | −7.224*              | −2.760             | −3.404               | −1.964               | −4.480               | −3.792               | −5.955*             |
| Columbus, OH                              | 2.1 M     | 0.0002%                   | −9.969**             | −9.256*            | −6.671               | −8.199*              | −8.942*              | −3.457               | 1.107               |
| Indianapolis-Carmel-Anderson, IN          | 2.1 M     | 0.0007%                   | −17.628**            | −11.337**          | −8.758**             | −7.329*              | −4.065               | −1.771               | −2.923              |
| Cleveland-Elyria, OH                      | 2.0 M     | 0.0004%                   | −16.725**            | −11.995**          | −8.420*              | −6.900               | −4.217               | −8.608*              | −4.007              |
| San Jose-Sunnyvale-Santa Clara, CA        | 2.0 M     | 0.0006%                   | −15.195**            | −15.272**          | −5.961               | −8.403*              | −6.517               | −8.492*              | −9.730**            |
| Nashville-Davidson--Murf.-Franklin, TN    | 1.9 M     | 0.0005%                   | −16.234**            | −10.733**          | −4.988               | −9.751**             | −1.787               | −0.698               | −0.443              |
| Virg. Beach-Norf.-Newp. News, VA-NC       | 1.8 M     | 0.0002%                   | −7.641               | −0.736             | −4.836               | −9.247*              | −0.490               | −5.783               | −5.136              |
| Providence-Warwick, RI-MA                 | 1.6 M     | 0.0004%                   | −11.807**            | −11.905**          | −8.814**             | −7.467**             | −7.210**             | −2.545               | −5.621*             |
| Milwaukee-Waukesha, WI                    | 1.6 M     | 0.0005%                   | −15.104**            | −8.239*            | −3.308               | −4.001               | −0.411               | 2.206                | 2.935               |
| Jacksonville, FL                          | 1.6 M     | 0.0002%                   | −3.984               | −3.603             | −5.792               | −1.906               | −9.438*              | −7.719*              | −8.991*             |

(Continues)
|                          | 2019 Pop. | March 2020 Infection Rate | Apr. Emp. Rate Diff. | May Emp. Rate Diff. | June Emp. Rate Diff. | July Emp. Rate Diff. | Aug. Emp. Rate Diff. | Sep. Emp. Rate Diff. | Oct. Emp. Rate Diff. |
|--------------------------|----------|---------------------------|---------------------|-------------------|---------------------|---------------------|--------------------|---------------------|--------------------|
| Oklahoma City, OK        | 1.4 M    | 0.0002%                   | −12.374**           | −9.887**          | −3.021              | −4.447              | −1.721             | 5.094               | 2.545              |
| Raleigh-Cary, NC         | 1.4 M    | 0.0002%                   | −13.180**           | −10.488           | −3.582              | −6.384              | −0.095             | 4.311               | 5.549              |
| Memphis, TN-MS-AR        | 1.3 M    | 0.0005%                   | −9.167*             | −10.112*          | −8.400              | −9.908*             | −6.217             | −7.435              | −2.658              |
| Richmond, VA             | 1.3 M    | 0.0001%                   | −5.458              | −3.910            | 0.344               | −3.002              | −0.867             | −0.413              | −0.438              |
| New Orleans-Metairie, LA | 1.3 M    | 0.0028%                   | −21.005**           | −13.462**         | −10.379**           | −5.474              | −4.172             | −2.368              | −3.126              |
| Louisville/Jefferson County, KY-IN | 1.3 M | 0.0002% | −9.200* | −2.232 | −5.088 | −4.767 | −4.921 | −11.431** | −8.691* |
| Salt Lake City, UT       | 1.2 M    | 0.0003%                   | −6.652              | −2.552            | 3.182               | −6.455*             | −4.098             | −4.447              | −6.222*             |
| Hartford-East Hartford-Middletown, CT | 1.2 M | 0.0004% | −0.834 | −6.642 | −3.559 | 1.648 | −1.933 | −6.435 | −7.887* |
| Buffalo-Cheektowaga, NY  | 1.1 M    | 0.0004%                   | −16.059**           | −11.446*          | −5.512              | −0.412              | −6.662             | −10.924*            | −8.467              |
| Birmingham-Hoover, AL    | 1.1 M    | 0.0004%                   | −11.931**           | −5.096            | −4.002              | −7.840*             | −3.877             | −8.109*             | −3.328              |

Note: The full sample includes civilians age 16 and over.
*Significant at 5% level; **Significant at 1% level.
### TABLE A3 Employed at work regression results omitting agriculture and mining controls

|                              | Apr–May | Jun–Aug | Sep–Oct |
|------------------------------|---------|---------|---------|
| MSA Pop. 100–250 K × 2020    | 0.173   | −0.083  | −1.444  |
|                              | (1.036) | (0.910) | (0.963) |
| MSA Pop. 250–500 K × 2020    | 1.070   | −2.245* | −1.675  |
|                              | (1.092) | (0.976) | (0.955) |
| MSA Pop. 500 K–1 M × 2020    | 1.190   | −0.420  | −0.902  |
|                              | (1.174) | (0.863) | (0.981) |
| MSA Pop. 1–2.5 M × 2020      | 0.445   | −2.191* | −1.319  |
|                              | (1.347) | (0.989) | (1.147) |
| MSA Pop. 2.5–5 M × 2020      | −0.092  | −1.710  | −0.976  |
|                              | (1.595) | (1.168) | (1.173) |
| MSA Pop. 5 M+ × 2020         | −0.086  | −1.975  | −1.208  |
|                              | (1.720) | (1.281) | (1.284) |
| Ln COVID Case Rate March 2020 × 2020 | −0.972* | −0.652  | −0.811* |
|                              | (0.440) | (0.401) | (0.379) |
| Ln COVID Case Rate Current × 2020 | −0.418 | −0.043  | −1.242* |
|                              | (0.308) | (0.406) | (0.525) |
| % Occ. Can Work from Home × 2020 | 0.068   | −0.033  | 0.062   |
|                              | (0.109) | (0.090) | (0.090) |
| % Employed in Construction × 2020 | −0.162 | −0.033  | 0.08    |
|                              | (0.192) | (0.158) | (0.173) |
| % Emp. Wholesale/Retail × 2020 | −0.07   | 0.08    | 0.242   |
|                              | (0.167) | (0.161) | (0.140) |
| % Emp. Transportation/Utilities × 2020 | 0.193   | −0.170  | −0.08   |
|                              | (0.165) | (0.140) | (0.135) |
| % Emp. Professional Services × 2020 | −0.205 | −0.002  | −0.013  |
|                              | (0.148) | (0.110) | (0.117) |
| % Emp. Education/Health × 2020 | 0.114   | 0.027   | 0.106   |
|                              | (0.089) | (0.076) | (0.080) |
| % Emp. Leisure/Hospitality × 2020 | −0.525** | −0.323  | −0.064  |
|                              | (0.136) | (0.174) | (0.135) |
| % Employed in Other Services × 2020 | −0.222 | 0.126   | 0.255   |
|                              | (0.327) | (0.279) | (0.316) |
| % Emp. Public Administration × 2020 | 0.113  | 0.109   | 0.160   |
|                              | (0.134) | (0.100) | (0.119) |
| Local Area Fixed Effects     | Yes     | Yes     | Yes     |
| Indiv. Characteristics × Time Dummies | Yes     | Yes     | Yes     |
| State × Time Dummies         | Yes     | Yes     | Yes     |
| F-Test p-Value for Industry Variables | 0.0001  | 0.649   | 0.582   |
|                              | 0.281   | 0.252   | 0.279   |
| Observations                 | 327,795 | 482,332 | 346,019 |

Note: The specification is similar to Column 4 of Tables 3–5 except local area employment percentage controls for agriculture and mining are now excluded; this means the omitted industry group includes manufacturing, agriculture, and mining.

*Significantly different from zero at 5% level; **Significant at 1% level.
### TABLE A4  
April–May 2019–2020 regression results by education group

|                  | (1)                  | (2)                  | (3)                  | (4)                  | (5)                  | (6)                  |
|------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
|                  | No college           | College educated     | Difference (1)−(2)   | No college           | College educated     | Difference (4)−(5)   |
| MSA Pop. 100–250 K × 2020 | −4.221** (1.528)   | 0.570 (1.583)        | −4.791* (2.061)      | 0.310 (1.504)        | 1.757 (1.341)        | −1.447 (1.921)       |
| MSA Pop. 250–500 K × 2020 | −4.647** (1.438)   | −1.836 (1.333)       | −2.812 (1.993)       | 1.019 (1.425)        | 1.764 (1.461)        | −0.745 (1.988)       |
| MSA Pop. 500 K–1 M × 2020 | −3.213** (1.172)   | −1.357 (1.222)       | −1.857 (1.454)       | 2.032 (1.642)        | 1.674 (1.380)        | 0.357 (1.992)        |
| MSA Pop. 1–2.5 M × 2020 | −4.826** (1.361)   | −2.997* (1.283)      | −1.829 (1.641)       | 3.296 (2.114)        | −0.453 (1.573)       | 3.749 (2.455)        |
| MSA Pop. 2.5–5 M × 2020 | −5.857** (1.762)   | −3.298 (1.709)       | −2.559 (1.638)       | 2.315 (2.395)        | −0.230 (1.844)       | 2.545 (2.776)        |
| MSA Pop. 5 M+ × 2020 | −7.460** (1.285)   | −4.283** (1.344)     | −3.177* (1.333)      | 2.304 (2.750)        | −0.856 (1.946)       | 3.159 (3.120)        |
| Year 2020 Dummy  | −7.988** (0.739)    | −7.901** (0.886)     | −0.087 (1.040)       |                      |                      |                      |

|                  | Ln COVID Case Rate March 2020 × 2020 | −1.032 (0.677) | −1.085* (0.537) | 0.054 (0.837) |
|                  | Ln COVID Case Rate Current × 2020   | −0.317 (0.533) | −0.358 (0.374) | 0.042 (0.669) |
|                  | % Occ. Can Work from Home × 2020    | 0.001 (0.169)  | 0.142 (0.141)  | −0.141 (0.219) |
|                  | % Employed in Agriculture × 2020    | 0.423* (0.208) | 0.263 (0.144)  | 0.160 (0.246) |
|                  | % Employed in Mining × 2020         | 0.138 (0.330)  | 0.260 (0.172)  | −0.122 (0.309) |
|                  | % Employed in Construction × 2020   | −0.083 (0.288) | −0.013 (0.230) | −0.070 (0.361) |
|                  | % Emp. Wholesale/Retail × 2020      | 0.121 (0.264)  | 0.054 (0.205)  | 0.067 (0.334) |
|                  | % Emp. Transportation/Utilities × 2020 | 0.516 (0.306) | 0.066 (0.217)  | 0.450 (0.400) |
|                  | % Emp. Professional Services × 2020 | −0.186 (0.226) | −0.033 (0.175) | −0.153 (0.276) |
|                  | % Emp. Education/Health × 2020      | 0.277 (0.152)  | 0.138 (0.112)  | 0.139 (0.197) |
|                  | % Emp. Leisure/Hospitality × 2020   | −0.380* (0.190) | −0.420* (0.193) | 0.040 (0.276) |

(Continues)
### TABLE A4 (Continued)

|                      | (1)                      | (2)                      | (3)                      | (4)                      | (5)                      | (6)                      |
|----------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
|                      | No college               | College educated         | Difference (1)−(2)       | No college               | College educated         | Difference (4)−(5)       |
| % Employed in Other  |                          |                          |                          |                          |                          |                          |
| Services × 2020      | 0.028                    | −0.054                   | 0.082                    | (0.512)                  | (0.396)                  | (0.631)                  |
| % Emp. Public        |                          |                          |                          |                          |                          |                          |
| Administration × 2020| 0.031                    | 0.187                    | −0.156                   | (0.204)                  | (0.145)                  | (0.235)                  |
| Local Area Fixed     | Yes                      | Yes                      | Yes                      | Yes                      | Yes                      | Yes                      |
| Effects              |                          |                          |                          |                          |                          |                          |
| Indiv. Characteristics | No                       | No                       | No                       | Yes                      | Yes                      | Yes                      |
| × Time Dummies       |                          |                          |                          |                          |                          |                          |
| State × Time Dummies | No                       | No                       | No                       | Yes                      | Yes                      | Yes                      |
| F-Test p-Value for   |                          |                          |                          |                          |                          |                          |
| Industry Variables   | 0.009                    | 0.012                    | 0.012                    |                          |                          |                          |
| R²                   | 0.030                    | 0.025                    | 0.059                    | 0.261                    | 0.267                    | 0.288                    |
| Observations         | 130,951                  | 196,844                  | 327,795                  | 130,951                  | 196,844                  | 327,795                  |

**Note:** The specification is otherwise similar to the main analysis except Columns 1 and 4 are limited to persons with no college education and Columns 2 and 5 are limited to persons with at least some college education. Columns 3 and 6 report the differences in coefficients between the two groups with standard errors estimated via pooled sample regression with a full set of interaction terms between a no college dummy and all other explanatory variables.

*Significantly different from zero at 5% level; **Significant at 1% level.

### TABLE A5 June–August 2019–2020 regression results by education group

|                      | (1)                      | (2)                      | (3)                      | (4)                      | (5)                      | (6)                      |
|----------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
|                      | No college               | College educated         | Difference (1)−(2)       | No college               | College educated         | Difference (4)−(5)       |
| MSA Pop. 100–250 K   | −2.704*                  | 0.310                    | −3.015                   | −0.644                   | 0.243                    | −0.888                   |
| × 2020               | (1.346)                  | (1.244)                  | (1.634)                  | (1.409)                  | (1.139)                  | (1.768)                  |
| MSA Pop. 250–500 K   | −4.734**                 | −3.885**                 | −0.849                   | −2.271                   | −1.931                   | −0.340                   |
| × 2020               | (1.309)                  | (1.339)                  | (1.772)                  | (1.455)                  | (1.326)                  | (2.023)                  |
| MSA Pop. 500 K–1 M   | −2.925**                 | −2.113*                  | −0.812                   | 0.749                    | −1.217                   | 1.966                    |
| × 2020               | (1.072)                  | (0.955)                  | (1.296)                  | (1.451)                  | (1.113)                  | (1.942)                  |
| MSA Pop. 1–2.5 M     | −5.508**                 | −3.498**                 | −2.009                   | 0.024                    | −3.480**                 | 3.504                    |
| × 2020               | (1.166)                  | (0.957)                  | (1.347)                  | (1.668)                  | (1.331)                  | (2.281)                  |
| MSA Pop. 2.5–5 M     | −6.343**                 | −3.997**                 | −2.345                   | 0.930                    | −3.749*                  | 4.678                    |
| × 2020               | (1.406)                  | (1.222)                  | (1.743)                  | (1.780)                  | (1.528)                  | (2.439)                  |
| MSA Pop. 5 M+ ×      | −6.201**                 | −4.163**                 | −2.037                   | −0.032                   | −3.285*                  | 3.253                    |
| 2020                 | (1.138)                  | (1.082)                  | (1.318)                  | (2.050)                  | (1.652)                  | (2.710)                  |
| Year 2020 Dummy      | −2.405**                 | −2.120**                 | −0.285                   | (0.546)                  | (0.727)                  | (0.755)                  |

(Continues)
|                           | (1) No college | (2) College educated | (3) Difference (1)−(2) | (4) No college | (5) College educated | (6) Difference (4)−(5) |
|---------------------------|---------------|----------------------|------------------------|---------------|----------------------|------------------------|
| Ln COVID Case Rate        |               |                      |                        |               |                      |                        |
| March 2020 × 2020          | −0.288        | −0.816               | 0.528                  | (0.597)       | (0.495)               | (0.750)                |
| Ln COVID Case Rate        |               |                      |                        |               |                      |                        |
| Current × 2020             | −1.218        | 0.584                | −1.802*                | (0.656)       | (0.454)               | (0.750)                |
| % Occ. Can Work from      |               |                      |                        |               |                      |                        |
| Home × 2020                | −0.210        | 0.044                | −0.254                 | (0.155)       | (0.126)               | (0.211)                |
| % Employed in             |               |                      |                        |               |                      |                        |
| Agriculture × 2020         | −0.236        | −0.028               | −0.208                 | (0.170)       | (0.152)               | (0.251)                |
| % Employed in             |               |                      |                        |               |                      |                        |
| Mining × 2020              | −0.271        | 0.090                | −0.362                 | (0.182)       | (0.276)               | (0.364)                |
| % Employed in             |               |                      |                        |               |                      |                        |
| Construction × 2020        | −0.008        | −0.200               | 0.192                  | (0.234)       | (0.224)               | (0.315)                |
| % Emp. Wholesale/         |               |                      |                        |               |                      |                        |
| Retail × 2020              | 0.068         | 0.054                | 0.014                  | (0.257)       | (0.209)               | (0.319)                |
| % Emp. Transportation/    |               |                      |                        |               |                      |                        |
| Utilities × 2020           | −0.467*       | −0.013               | −0.455                 | (0.223)       | (0.183)               | (0.293)                |
| % Emp. Professional       |               |                      |                        |               |                      |                        |
| Services × 2020            | −0.100        | 0.045                | −0.145                 | (0.191)       | (0.159)               | (0.268)                |
| % Emp. Education/         |               |                      |                        |               |                      |                        |
| Health × 2020              | −0.002        | 0.001                | −0.003                 | (0.137)       | (0.103)               | (0.180)                |
| % Emp. Leisure/           |               |                      |                        |               |                      |                        |
| Hospitality × 2020         | −0.508*       | −0.270               | −0.238                 | (0.225)       | (0.205)               | (0.235)                |
| % Employed in             |               |                      |                        |               |                      |                        |
| Other Services × 2020      | −0.166        | 0.195                | −0.361                 | (0.465)       | (0.379)               | (0.620)                |
| % Emp. Public             |               |                      |                        |               |                      |                        |
| Administration × 2020      | 0.294         | −0.004               | 0.298                  | (0.187)       | (0.150)               | (0.265)                |
| Local Area Fixed Effects   | Yes           | Yes                  | Yes                    | Yes           | Yes                  | Yes                    |
| Indiv. Characteristics ×   | No            | No                   | No                     | Yes           | Yes                  | Yes                    |
| Time Dummies               |               |                      |                        |               |                      |                        |
| State × Time Dummies       | No            | No                   | No                     | Yes           | Yes                  | Yes                    |
| F-Test p-Value for         |               |                      |                        |               |                      |                        |
| Industry Variables         | 0.166         | 0.968                | 0.968                  |               |                      |                        |
| $R^2$                      | 0.019         | 0.014                | 0.038                  | 0.248         | 0.235                | 0.258                  |
| Observations               | 192,498       | 289,834              | 482,332                | 192,498       | 289,834              | 482,332                |

Notes: The specification is otherwise similar to the main analysis except Columns 1 and 4 are limited to persons with no college education and Columns 2 and 5 are limited to persons with at least some college education. Columns 3 and 6 report the differences in coefficients between the two groups with standard errors estimated via pooled sample regression with a full set of interaction terms between a no college dummy and all other explanatory variables.

*Significantly different from zero at 5% level; **Significant at 1% level.
TABLE A6  September–October 2019–2020 regression results by education group

|                        | (1) No college | (2) College educated | (3) Difference (1)−(2) | (4) No college | (5) College educated | (6) Difference (4)−(5) |
|------------------------|---------------|-----------------------|------------------------|---------------|-----------------------|------------------------|
| MSA Pop. 100−250 K × 2020 | −1.807        | 0.005                 | −1.812                | −2.233        | −0.594                | −1.639                 |
|                        | (1.625)       | (1.370)               | (1.968)                | (1.473)       | (1.155)               | (1.819)                |
| MSA Pop. 250−500 K × 2020 | −2.954*       | −2.159                | −0.796                | −2.942        | −0.449                | −2.494                 |
|                        | (1.438)       | (1.328)               | (2.095)                | (1.582)       | (1.219)               | (2.031)                |
| MSA Pop. 500 K−1 M × 2020 | −1.919        | −0.975                | −0.944                | −3.149*       | 0.920                 | −4.069*                |
|                        | (1.379)       | (1.054)               | (1.706)                | (1.504)       | (1.129)               | (1.800)                |
| MSA Pop. 1−2.5 M × 2020 | −2.584        | −0.680                | −1.904                | −3.291        | 0.187                 | −3.478                 |
|                        | (1.326)       | (1.127)               | (1.593)                | (1.895)       | (1.348)               | (2.323)                |
| MSA Pop. 2.5−5 M × 2020 | −5.255**      | −1.745                | −3.510*               | −4.340*       | 1.036                 | −5.376*                |
|                        | (1.457)       | (1.124)               | (1.751)                | (2.024)       | (1.394)               | (2.433)                |
| MSA Pop. 5 M+ × 2020    | −4.353**      | −2.760**              | −1.594                | −2.969        | −0.107                | −2.862                 |
|                        | (1.128)       | (0.954)               | (1.337)                | (2.301)       | (1.553)               | (2.800)                |
| Year 2020 Dummy        | −1.711        | −2.873**              | 1.162                 | (Continues)   |                       |                       |
|                  | (1) No college | (2) College educated | Difference (1)−(2) | (3) No college | (4) College educated | Difference (4)−(5) |
|------------------|---------------|----------------------|-------------------|---------------|----------------------|-------------------|
| % Employed in Other Services × 2020 | 0.152 (0.499) | 0.380 (0.385) | −0.228 (0.615) |
| % Emp. Public Administration × 2020 | 0.379 (0.204) | 0.003 (0.117) | 0.376 (0.217) |
| Local Area Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Indiv. Characteristics × Time Dummies | No | No | No | Yes | Yes | Yes |
| State × Time Dummies | No | No | No | Yes | Yes | Yes |
| F-Test p-Value for Industry Variables | 0.002 | 0.227 | 0.228 |
| $R^2$ | 0.015 | 0.015 | 0.042 | 0.262 | 0.266 | 0.285 |
| Observations | 139,347 | 206,672 | 346,019 | 139,347 | 206,672 | 346,019 |

Note: The specification is otherwise similar to the main analysis except Columns 1 and 4 are limited to persons with no college education and Columns 2 and 5 are limited to persons with at least some college education. Columns 3 and 6 report the differences in coefficients between the two groups with standard errors estimated via pooled sample regression with a full set of interaction terms between a no college dummy and all other explanatory variables.

*Significantly different from zero at 5% level; **Significant at 1% level.
|                | (1)          | (2)          | (3)          | (4)          | (5)          | (6)          |
|----------------|--------------|--------------|--------------|--------------|--------------|--------------|
| MSA Pop. <1 M × 2020 | −2.006*      | −1.286       | −0.789       | 1.412        | 1.379        | 1.231        |
|                | (0.783)      | (0.721)      | (0.745)      | (0.874)      | (0.881)      | (0.888)      |
| MSA Pop. 1 M+ × 2020 | −4.489**     | −4.258**     | −3.616**     | 0.664        | 0.560        | 0.111        |
|                | (0.913)      | (0.851)      | (0.764)      | (1.197)      | (1.193)      | (1.195)      |
| Year 2020 Dummy | −7.796**     |              |              |              |              |              |
|                | (0.630)      |              |              |              |              |              |

|                |            | −1.107*      | −1.310**     |              |              |              |
|                |            | (0.451)      | (0.474)      |              |              |              |
| Ln COVID Case Rate |            | −0.399       | −0.785*      |              |              |              |
| March 2020 × 2020 |            | (0.283)      | (0.331)      |              |              |              |
| Ln COVID Case Rate |            |              | −0.785*      |              |              |              |
| Current × 2020   |            |              | (0.331)      |              |              |              |
| % Occ. Can Work from | 0.114      | 0.126        | 0.107        |              |              |              |
| Home × 2020      | (0.107)     | (0.107)      | (0.106)      |              |              |              |
| % Employed in Agriculture × 2020 | 0.333*      | 0.344**      | 0.280*       |              |              |              |
|                | (0.133)     | (0.132)      | (0.138)      |              |              |              |
| % Employed in Mining × 2020 | 0.106      | 0.136        | 0.101        |              |              |              |
|                | (0.226)     | (0.228)      | (0.227)      |              |              |              |
| % Employed in Construction × 2020 | −0.050      | −0.028       | −0.124       |              |              |              |
|                | (0.192)     | (0.190)      | (0.196)      |              |              |              |
| % Emp. Wholesale/Retail × 2020 | 0.029       | 0.052        | 0.058        |              |              |              |
|                | (0.161)     | (0.163)      | (0.164)      |              |              |              |
| % Emp. Transportation/Utilities × 2020 | 0.245       | 0.223        | 0.169        |              |              |              |
|                | (0.171)     | (0.175)      | (0.183)      |              |              |              |
| % Emp. Professional Services × 2020 | −0.130      | −0.122       | −0.203       |              |              |              |
|                | (0.141)     | (0.141)      | (0.140)      |              |              |              |
| % Emp. Education/Health × 2020 | 0.169       | 0.186*       | 0.116        |              |              |              |
|                | (0.088)     | (0.088)      | (0.090)      |              |              |              |
| % Emp. Leisure/Hospitality × 2020 | −0.433**    | −0.415**     | −0.458**     |              |              |              |
|                | (0.143)     | (0.144)      | (0.150)      |              |              |              |
| % Emp. Other Services × 2020 | −0.097      | −0.142       | −0.120       |              |              |              |
|                | (0.329)     | (0.329)      | (0.332)      |              |              |              |
| % Emp. Public Administration × 2020 | 0.106       | 0.104        | 0.130        |              |              |              |
|                | (0.134)     | (0.133)      | (0.135)      |              |              |              |
| Local Area Fixed Effects | Yes      | Yes          | Yes          | Yes          | Yes          | Yes          |
| Indiv. Characteristics × Time Dummies | No      | Yes          | Yes          | Yes          | Yes          | Yes          |
| State × Time Dummies | No      | No           | Yes          | Yes          | Yes          | Yes          |
| $F$-Test p-Value for Industry Variables |            | < 0.0001     | < 0.0001     | < 0.0001     | < 0.0001     | < 0.0001     |
| $R^2$ | 0.025       | 0.280        | 0.281        | 0.281        | 0.281        | 0.281        |
| Observations | 327,795     | 327,795      | 327,795      | 327,795      | 327,795      | 327,795      |

*Note: The specification is otherwise similar to the main analysis except it uses two broad MSA group indicators (interacted with year 2020) instead of the six MSA groups in the main analysis. Specifically, MSA Pop. <1 M refers to all MSAs with population less than one million and MSA Pop. 1 M+ refers to all MSAs with population greater than one million. Non-MSAs are again the omitted reference group.

*Significantly different from zero at 5% level; **Significant at 1% level.
### Table A8: June–August 2019–2020 Regression Results with Broader MSA Groups

|                          | (1)       | (2)       | (3)       | (4)       | (5)       | (6)       |
|--------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| MSA Pop. <1 M × 2020     | −2.576**  | −1.949**  | −1.694**  | −1.181    | −1.205    | −1.279    |
|                          | (0.682)   | (0.574)   | (0.560)   | (0.731)   | (0.719)   | (0.749)   |
| MSA Pop. 1 M+ × 2020     | −4.663**  | −4.312**  | −3.877**  | −2.330*   | −2.369*   | −2.685**  |
|                          | (0.692)   | (0.558)   | (0.533)   | (0.957)   | (0.943)   | (0.979)   |
| Year 2020 Dummy          | −2.008**  |           |           |           |           |           |
|                          | (0.539)   |           |           |           |           |           |
| Ln COVID Case Rate       |           | −0.554    | −0.559    |           |           |           |
| March 2020 × 2020        |           | (0.390)   | (0.386)   |           |           |           |
| Ln COVID Case Rate       |           | −0.064    | −0.131    |           |           |           |
| Current × 2020           |           | (0.397)   | (0.389)   |           |           |           |
| % Occ. Can Work from     | −0.059    | −0.058    | −0.061    |           |           |           |
| Home × 2020              |           | (0.091)   | (0.092)   |           |           |           |
| % Employed in Agriculture| −0.173    | −0.174    | −0.197    |           |           |           |
| × 2020                   |           | (0.103)   | (0.104)   |           |           |           |
| % Employed in Mining     | −0.112    | −0.111    | −0.099    |           |           |           |
| × 2020                   |           | (0.143)   | (0.144)   |           |           |           |
| % Employed in Construction| −0.085   | −0.083    | −0.119    |           |           |           |
| × 2020                   |           | (0.166)   | (0.166)   |           |           |           |
| % Emp. Wholesale/Retail | 0.051     | 0.052     | 0.079     |           |           |           |
| × 2020                   |           | (0.168)   | (0.169)   |           |           |           |
| % Emp. Transportation/  | −0.188    | −0.190    | −0.243    |           |           |           |
| Utilities × 2020         |           | (0.144)   | (0.143)   |           |           |           |
| % Emp. Professional      | −0.030    | −0.031    | −0.068    |           |           |           |
| Services × 2020          |           | (0.111)   | (0.111)   |           |           |           |
| % Emp. Education/Health  | 0.003     | 0.002     | −0.019    |           |           |           |
| × 2020                   |           | (0.076)   | (0.076)   |           |           |           |
| % Emp. Leisure/          | −0.404*   | −0.403*   | −0.410*   |           |           |           |
| Hospitality × 2020       |           | (0.176)   | (0.174)   |           |           |           |
| % Emp. Other Services    | −0.002    | −0.003    | −0.042    |           |           |           |
| × 2020                   |           | (0.265)   | (0.265)   |           |           |           |
| % Emp. Public Administration × 2020 | 0.124 | 0.124 | 0.139 | (0.101) | (0.101) | (0.100) |
| Local Area Fixed Effects | Yes       | Yes       | Yes       | Yes       | Yes       | Yes       |
| Indiv. Characteristics × Time Dummies | No | Yes | Yes | Yes | Yes | Yes |
| State × Time Dummies     | No        | No        | Yes       | Yes       | Yes       | Yes       |
| F-Test p-Value for Industry Variables | 0.483 | 0.483 | 0.273 |           |           |           |
| R²                       | 0.014     | 0.251     | 0.252     | 0.252     | 0.252     | 0.252     |
| Observations             | 482,332   | 482,332   | 482,332   | 482,332   | 482,332   | 482,332   |

**Note:** The specification is otherwise similar to the main analysis except it uses two broad MSA group indicators (interacted with year 2020) instead of the six MSA groups in the main analysis. Specifically, MSA Pop. <1 M refers to all MSAs with population less than one million and MSA Pop. 1 M+ refers to all MSAs with population greater than one million. Non-MSAs are again the omitted reference group.

*Significantly different from zero at 5% level; **Significant at 1% level.
### Table A9  September–October 2019–2020 regression results with broader MSA groups

|                          | (1)        | (2)        | (3)        | (4)        | (5)        | (6)        |
|--------------------------|------------|------------|------------|------------|------------|------------|
| MSA Pop. <1 M × 2020     | −1.754*    | −1.121     | −0.917     | −1.477     | −1.502     | −1.647     |
|                          | (0.763)    | (0.655)    | (0.652)    | (0.811)    | (0.809)    | (0.838)    |
| MSA Pop. 1 M+ × 2020     | −2.964**   | −2.494**   | −1.719*    | −1.541     | −1.598     | −2.088     |
|                          | (0.749)    | (0.682)    | (0.706)    | (1.083)    | (1.084)    | (1.118)    |
| Year 2020 Dummy          | −2.123**   |            |            |            |            |            |
|                          | (0.647)    |            |            |            |            |            |
| Ln COVID Case Rate       |            | −0.777*    | −0.725     |            |            |            |
| March 2020 × 2020        |            | (0.363)    | (0.370)    |            |            |            |
| Ln COVID Case Rate       |            | −1.345*    | −1.271*    |            |            |            |
| Current × 2020           |            | (0.546)    | (0.545)    |            |            |            |
| % Occ. Can Work from     | 0.054      | 0.059      | 0.054      |            |            |            |
| Home × 2020              | (0.091)    | (0.091)    | (0.092)    |            |            |            |
| % Employed in Agriculture × 2020 | −0.109 | −0.121     | −0.145     |            |            |            |
|                          | (0.130)    | (0.130)    | (0.129)    |            |            |            |
| % Employed in Mining     | −0.381*    | −0.344*    | −0.357*    |            |            |            |
| × 2020                   | (0.157)    | (0.153)    | (0.158)    |            |            |            |
| % Employed in Construction × 2020 | 0.020 | 0.045      | −0.025     |            |            |            |
|                          | (0.178)    | (0.178)    | (0.179)    |            |            |            |
| % Emp. Wholesale/Retail | 0.173      | 0.176      | 0.215      |            |            |            |
| × 2020                   | (0.139)    | (0.138)    | (0.139)    |            |            |            |
| % Emp. Transportation/Utilities × 2020 | −0.067 | −0.107     | −0.151     |            |            |            |
|                          | (0.136)    | (0.138)    | (0.127)    |            |            |            |
| % Emp. Professional Services × 2020 | −0.058 | −0.048     | −0.111     |            |            |            |
|                          | (0.119)    | (0.119)    | (0.117)    |            |            |            |
| % Emp. Education/Health | 0.067      | 0.053      | 0.036      |            |            |            |
| × 2020                   | (0.078)    | (0.079)    | (0.078)    |            |            |            |
| % Emp. Leisure/Hospitality × 2020 | −0.139 | −0.109     | −0.144     |            |            |            |
|                          | (0.133)    | (0.133)    | (0.133)    |            |            |            |
| % Emp. Other Services    | 0.237      | 0.193      | 0.178      |            |            |            |
| × 2020                   | (0.283)    | (0.288)    | (0.285)    |            |            |            |
| % Emp. Public Administration × 2020 | 0.136 | 0.147      | 0.157      |            |            |            |
|                          | (0.119)    | (0.118)    | (0.120)    |            |            |            |
| Local Area Fixed Effects | Yes        | Yes        | Yes        | Yes        | Yes        | Yes        |
| Indiv. Characteristics × Time Dummies | No | Yes        | Yes        | Yes        | Yes        | Yes        |
| State × Time Dummies     | No         | No         | Yes        | Yes        | Yes        | Yes        |
| F-Test p-Value for Industry Variables | 0.148 | 0.196      | 0.081      |            |            |            |
| R²                       | 0.013      | 0.278      | 0.279      | 0.279      | 0.279      | 0.279      |
| Observations             | 346,019    | 346,019    | 346,019    | 346,019    | 346,019    | 346,019    |

*Significantly different from zero at 5% level; **Significant at 1% level.

Note: The specification is otherwise similar to the main analysis except it uses two broad MSA group indicators (interacted with year 2020) instead of the six MSA groups in the main analysis. Specifically, MSA Pop. <1 M refers to all MSAs with population less than one million and MSA Pop. 1 M+ refers to all MSAs with population greater than one million. Non-MSAs are again the omitted reference group.