



Nursing facilities, food manufacturing plants and COVID-19 cases and deaths

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ARTICLE INFO

Article history:

Received 10 November 2020

Received in revised form 14 February 2021

Accepted 21 February 2021

Available online 25 February 2021

JEL classification:

I18

Keywords:

COVID-19

Prevalence

Essential businesses

Nursing homes

Meatpacking plants

ABSTRACT

News outlets pointed to meatpacking plants and nursing homes as viral hotspots during the first wave of the COVID-19 pandemic in the US. In contrast to news reports, we find that retirement communities and assisted living facilities were associated with fewer cases and deaths and that skilled nursing facilities were associated with fewer cases. We find that meatpacking plants were associated with more cases and deaths as were bakeries. In contrast dairy plants were associated with fewer cases and deaths. Proactive implementation of policy measures in nursing homes and retirement facilities were beneficial. Analogous guidance was lacking for food manufacturing establishments, potentially exacerbating the spread of the virus.

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1. Introduction

Early in the COVID-19 pandemic, news outlets highlighted potential viral hotspots within certain environments. Essential services including nursing homes and meatpacking plants were scrutinized (Dickerson and Jordan, 2020; Wilson and Kummerer, 2020) to the extent that a *The New York Times* article claimed that meatpacking plants and nursing homes were “proven to be places where the virus spreads rapidly” (Corkery et al. (2020)). Outbreaks in residential care homes were attributed to the proximity of vulnerable individuals, while poor working conditions were blamed for outbreaks at meatpacking plants (Ellis and Hicken, 2020; Chavez and Karimi, 2020; Wilson and Kummerer, 2020). However, there is no systematic quantitative evidence to support or refute these claims, to date.

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The aim of this article is to examine the relationship between the geographic concentration of two industries – nursing and residential care facilities, and food manufacturing establishments – and COVID-19 cases and deaths during the first wave of the pandemic in the US (through May 28, 2020). Although the study design is not explicitly causal, our findings suggest that industry-based mitigation strategies could have lowered the prevalence of the disease.

2. Data

We constructed two datasets, one with the Hospital Referral Region (HRR) (Dartmouth Atlas, 2020) as the unit of observation and the other with Metropolitan Statistical Area (MSA) (US Census Bureau, 2020) as the unit of observation, using a number of publicly available sources.

We measured cumulative cases and deaths through May 28, 2020 using data from the Johns Hopkins Center for Systems Science and Engineering (Center for Systems Science and Engineering, 2020). We ended measurement on May 28, 2020 rather than on May 31, 2020 because May 31 was a Sunday. Weekend reporting is suspect given the lower cases and deaths on most weekends and compensating spikes most Mondays. They are both updated daily at the county level with a few exceptions. The most notable exception is that of measurement in the five boroughs of

New York City. Each borough is a county with a set of stipulations for reporting cases and death. We used the New York City Department of Health and Mental Hygiene's coronavirus-data GitHub repository (NYC) to apportion the New York City cases and deaths to the five boroughs (counties) (NYC Department of Health and Mental Hygiene, 2020).

We obtained data on the number of business establishments by industry and county from the US Bureau of Labor Statistics' Quarterly Census of Employment and Wages (QCEW) (Bureau of Labor Statistics, 2020b). The QCEW surveys 95% of U.S. jobs to obtain data on the number of establishments, monthly employment and quarterly wages at the county level. The measures are classified by industry using North American Industry Classification System (NAICS) (North American Industry Classification System, 2020).

The datasets include two groups of 4-digit NAICS industry classifications: nursing and residential care, and food manufacturing. Nursing and residential care consists of skilled nursing facilities (skilled nursing, NAICS code 6231), developmental disability, mental health, and substance abuse facilities (mental health, 6232), retirement communities and assisted living facilities (retirement communities, 6233) and other residential care facilities (6239). The food manufacturing industries in our data are grain and oilseed milling (cereal, NAICS code 3112), sugar and confectionery manufacturing (confectionery, 3113), fruit and vegetable preserving and specialty food manufacturing (fruit and vegetable preserving, 3114), dairy product manufacturing (dairy, 3115), animal slaughtering and processing (meatpacking, 3116), seafood product preparation and packaging (seafood preparation, 3117) and baked goods plants and tortilla manufacturing (bakery, 3118).

We used The National Cancer Institute's Surveillance, Epidemiology, and End Results Program's (SEER) 1990–2018 4 Expanded Races by Origin and Age file to compute county-level race and ethnicity specific populations for 2018 (Surveillance, Epidemiology, and End Results Program, 2020). County land area (Hornsby, 2020) was used in conjunction with the 2018 SEER population data to determine population density. County-level poverty rates were obtained from the USDA's Economic Research Service's Poverty dataset (United States Department of Agriculture, 2020).

Google documents mobility trends daily in a given area relative to a baseline day (Google Inc., 2020). We used county-level data to obtain the earliest dates on which mobility dropped by 25% in retail and recreation areas and increased by 15% in residential areas.

We obtained climate data by measuring station from the National Oceanic and Atmospheric Administration Global Historical Climatology Network (GHCN)-Daily dataset (Global Historical Climatology Network, 2020). We spatially merged weather stations to US counties and calculated county-level average daily maximum temperature over the period January 1, 2020 through February 29, 2020.

Data from Alaska and Hawaii were excluded from our analyses. We use data on 304 HRRs and 377 MSAs in the contiguous US in our statistical analysis.

3. Methods

We estimated Generalized Linear Models (GLM) with log link and Poisson density (McCullagh and Nelder, 1989). In addition to the variables mentioned above, our models control for time (measured as the number of days as of May 28, 2020) since the first death in the state in which the geographic unit is located. Poisson GLM models, robust to misspecification influence of few large outliers, have been used in recent literature by Kraemer et al. (2020) and Tobías and Molina (2020) to model COVID-19 outcomes. We used cluster robust standard errors for inference.

4. Results

Fig. 1 shows that there is substantial geographic variation in the number of establishments for nursing and residential care facilities and each food manufacturing industry. For each of these industries, several HRRs and MSAs have values that lie outside the upper quartile and a fair number have values outside the upper adjacent values.

In Fig. 2 we display the associations between nursing and residential care facilities and COVID-19 cases and deaths. At the HRR level, skilled nursing facilities are associated with 5% fewer cases and 5% fewer deaths. At the MSA level, however, the associations of skilled nursing facilities with cases and deaths are not statistically significant. An additional mental health care facility is associated with statistically significant 2% greater cases and deaths at the HRR level but such facilities are not significantly associated with cases and deaths across MSAs. Retirement communities and assisted living facilities are associated with statistically significant 6% fewer cases and deaths across HRRs and 4% fewer cases and deaths across MSAs. Other residential care facilities are generally not significantly associated with cases or deaths.

Fig. 2 also shows the associations between the geographic locations of food manufacturing establishments and COVID-19 cases and deaths. An additional dairy plant is associated with 13% fewer cases and 18% fewer deaths across HRRs, and 9% fewer cases ($p = 0.09$) and 17% fewer deaths across MSAs. An additional meatpacking plant is statistically significantly associated with 21% (16%) more cases across HRRs (MSAs). An additional meatpacking plant is also associated with 7% more deaths, but this effect is not significant at the MSA level. Although seafood plants are less common across the country, we show that they are associated with statistically significant 15% additional cases across HRRs and 13% across MSAs. An additional seafood plant is also associated with 14% (with $p = 0.16$) more deaths at the HRR level and 16% more deaths at the MSA level. Notably, the most common food production industry, baked goods plants, are associated with significantly more cases and deaths. An additional bakery establishment is associated with 14% and 9% more cases, and 13% and 10% more deaths at the HRR and MSA levels respectively. The associations between numbers of grain and oilseed milling establishments, sugar and confectionary manufacturing establishments, fruit and vegetable preserving and specialty food manufacturing and cases and deaths are not statistically significant.

In Fig. 3 we display the associations for all control variables. Population density is associated with 19% and 26% more deaths across HRRs and MSAs, respectively, and with 7% more cases at the HRR level. The association is not significant for cases at the MSA level. Moreover, a 1% increase in the proportion of the Black population is associated with more cases (4%–5%) and deaths (3%–4%) across HRRs and MSAs. In addition, a 1% increase in the Hispanic share of the population is associated with 1% and 2% more cases across HRRs and MSAs, respectively, but the association is not significant for deaths. The associations are not significant for other non-White population shares ($p > 0.16$). Poverty rates are not significantly associated with deaths. Poverty rates are, however, associated with fewer cases at both HRR and MSA levels, which is consistent with variation in testing and access to healthcare. A decline in mobility (to the thresholds specified above) starting a day earlier is associated with 1% and 2% fewer deaths across HRRs and MSAs, respectively, and with 1% fewer cases across MSAs. The associated is not statistically significant at the HRR level ($p = 0.5$). Finally, an increase in average winter temperatures (see above) by 1°C increase is associated with 4% and 5% fewer cases and 4% and 6% fewer deaths across HRRs and MSAs, respectively.

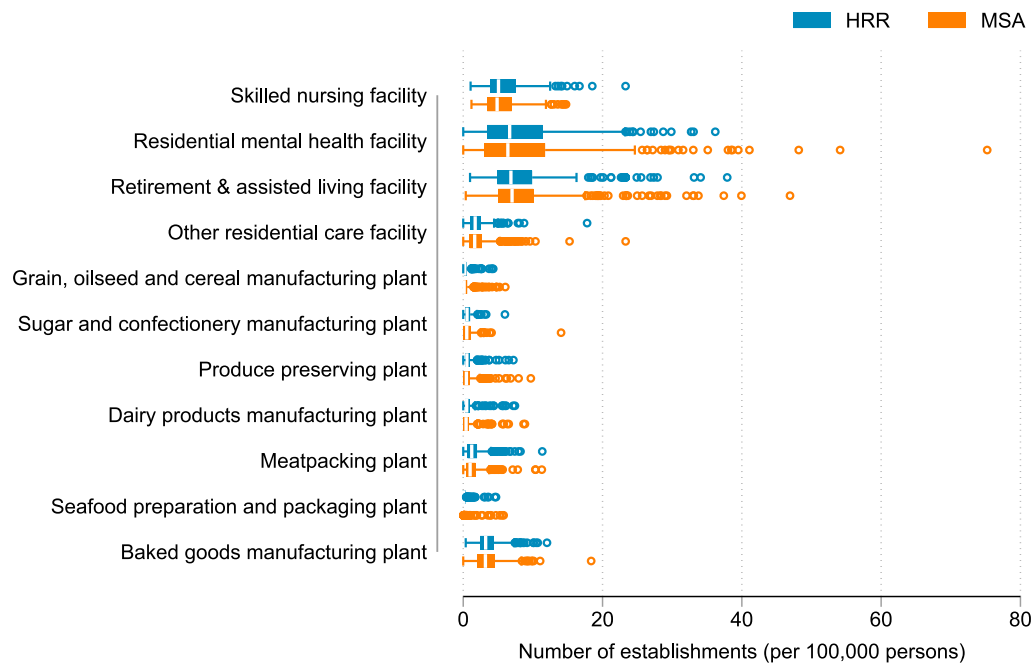


Fig. 1. Geographic distributions of nursing and residential care facilities and food products manufacturing establishments (per 100,000 persons). Notes: Each boxplot depicts the distribution of the number of business establishments. The box denotes lower, middle and upper quartiles. The whiskers indicate variability outside the upper and lower quartiles through upper and lower adjacent values. Outliers vis-a-vis the adjacent values are plotted as individual points.

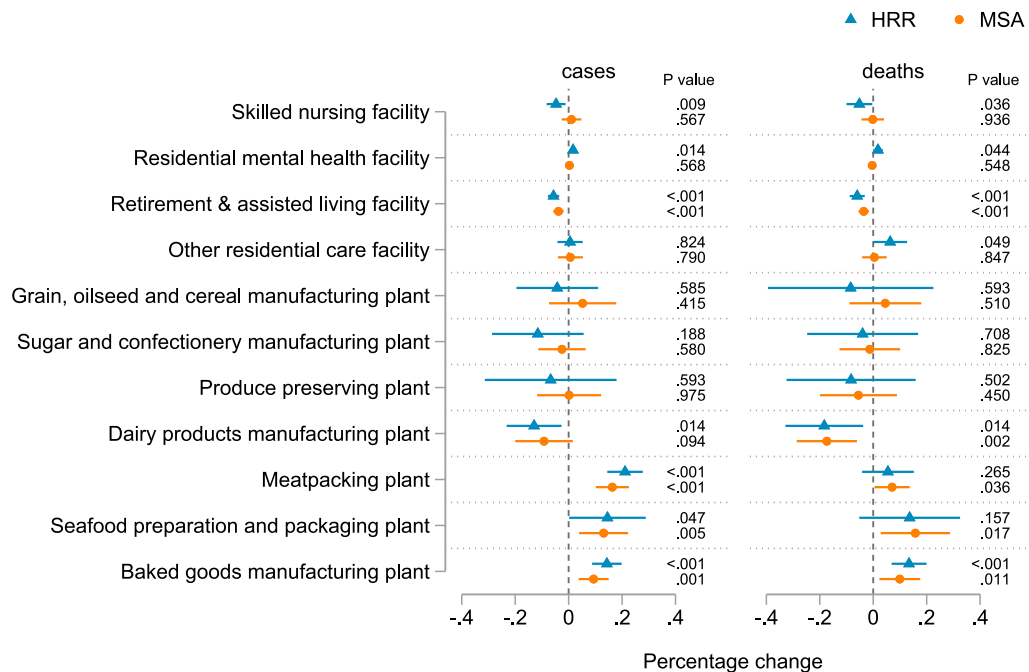


Fig. 2. Associations between nursing and residential care facilities and food products manufacturing establishments and cases and deaths (each per 100,000 persons). Notes: Regressions of cases and deaths per 100,000 persons and socioeconomic characteristics, temperature, and numbers of business establishments were estimated using generalized linear models with log link and Poisson family. The error bars indicate 95% confidence intervals.

4.1. Sensitivity analyses

We conducted a number of sensitivity analyses to examine the robustness our findings. First, we excluded the observations for the HRRs and MSA that encompass New York City. Second, we excluded geographic units in states that did not formally issue shelter-in-place orders, namely, Iowa, North Dakota, Oklahoma, South Dakota, and Utah. Third, we excluded tortilla manufacturing, a niche product, from counts of baked goods plants. Fourth,

we checked the models' sensitivity to alternative specifications of changes in mobility using combinations of 20% and 25% drops in retail and recreation areas and increases in movement between 15% and 20% increases in residential areas as targets to ascertain the earliest public response dates. Finally, we checked the models' sensitivity to alternative definitions of temperature. We find (results available upon request) that the estimates of associations between food production establishments and nursing and

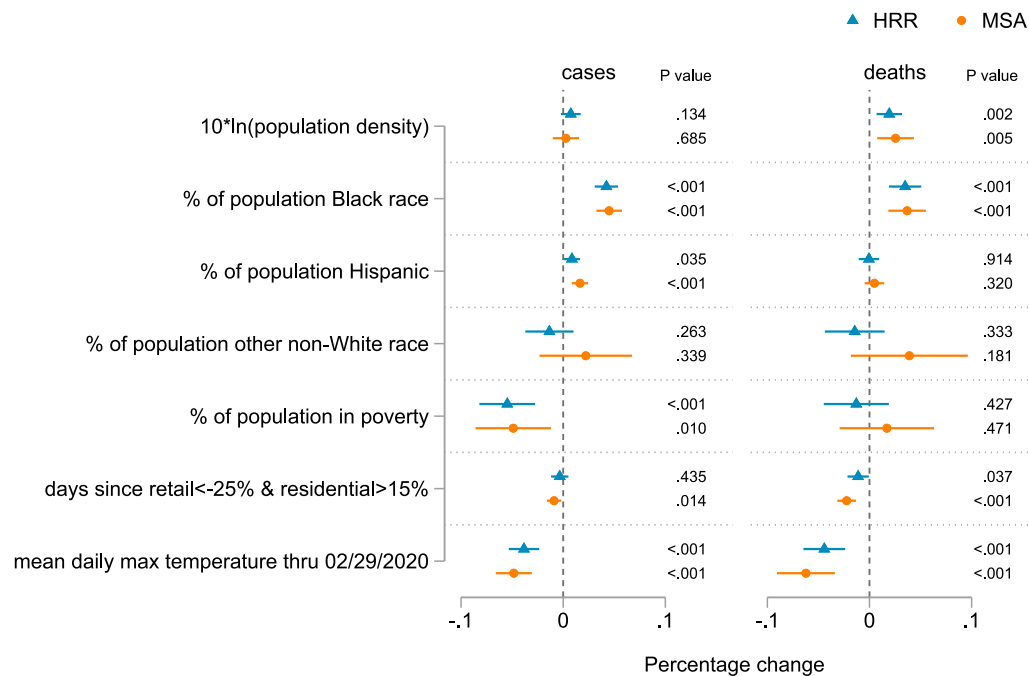


Fig. 3. Associations between demographic and geographic characteristics and cases and deaths (each per 100,000 persons). Notes: Regressions of cases and deaths per 100,000 persons and socioeconomic characteristics, temperature, and numbers of business establishments were estimated using generalized linear models with log link and Poisson family. The error bars indicate 95% confidence intervals.

residential care facilities with cases and deaths are qualitatively unchanged from our primary analysis.

5. Conclusions

In this study, we examined the relationships between the geographic concentration of two industries that remained open through the initial shelter-in-place orders, and COVID-19 cases and deaths during the first wave of the pandemic in the US. Our results suggest that residential elder care establishments were associated with lower COVID-19 cases and deaths. This finding contrasts with press reports that nursing homes have suffered COVID-19 outbreaks (Corkery et al., 2020; Dickerson and Jordan, 2020; Wilson and Kummerer, 2020). Our regression results and these press reports are, however, not inconsistent. It is likely that many skilled nursing facilities, retirement communities and assisted living facilities, heeded authoritative warnings about the risks of COVID-19 and implemented mitigation measures (Barnett and Grabowski, 2020; Goldstein et al., 2020). Given that the elderly have been substantially more likely to suffer the worst symptoms of the disease and die from it, our results suggest that nursing and residential care facilities have actually been protective.

Our results show that meatpacking plants were associated with substantially higher cases and plausibly substantially higher deaths. These findings are consistent with news reports that have centered the narrative on poor working conditions in these plants. Almost no media attention has been placed on seafood plants and baked goods plants, which were also similarly associated with more cases and deaths. Meanwhile, dairy product manufacturing establishments were associated with substantially fewer cases and deaths. While poor working conditions may explain more cases and deaths in meatpacking plants and seafood facilities, the significant associations with baked goods plants and dairies point to an alternative explanation. We examined capital to labor ratios and wages in these industries using productivity data from the Bureau of Labor Statistics and found that the

three industries associated with more deaths and cases have the lowest capital to labor ratios among food production industries and employ workers at the lowest hourly wages (Bureau of Labor Statistics, 2020a). Establishments in these industries employ many workers for production, packaging and sorting tasks who work in close proximity (Sinha, 2007). On the other end of the spectrum, dairy products manufacturing establishments have the second highest capital to labor ratio and the highest hourly wage rates. Dairy products manufacturing uses large-scale automated processes operated by higher skill workers (Kirkland, 1994; Sinha, 2007).

The estimates suggest that policy measures at the industry level had an impact on disease prevalence in the first wave of the pandemic in the US, subject to the caveat that the estimates are not strictly causal. Proactive implementation of mitigation strategies in nursing homes and retirement facilities appears to have been beneficial. On the other hand, meatpacking plants appear to have not received any guidance until April 26, 2020 and likely resisted implementing protection measures (U.S. Department of Labor, 2020; Telford, 2020). Proactive guidance on protective measures could have reduced disease burdens in those food manufacturing environments.

Acknowledgments

We are grateful to Ke Zeng for his insightful comments. Ishan Deb and Cheryn Ryoo provided excellent research assistance. All errors are our own.

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