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Publication Date

2023-08-01

DOI

10.1016/j.ajic.2023.07.008

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July 28, 2023

Word count (excluding References): 4,706

Post-print. Published in American Journal of Infection Control : Online first

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Abstract:

Background. This study investigated whether socioeconomic and demographic factors within spatial areas surrounding U.S. skilled nursing facilities related to the number of Covid-19 cases reported among residents, staff, and facility personnel and resident deaths.

Methods. We utilized data from the Nursing Home COVID-19 Public File, which includes data reported to the CDC's National Healthcare Safety Network (NHSN) system which tracked Covid-19 cases reported for 12,403 U.S. skilled nursing facilities among residents, staff, and facility personnel monthly from June 2020 to September 2022. We also utilized geographic information on the latitude and longitude of these facilities and demographic information on the residents and staff from the LTCFocus dataset and utilized data from the U.S. Census in 2010 and the American Community Survey 2012 5-year estimates. Dependent variables were cumulative case counts among 1) residents and 2) staff and facility personnel, as well as cumulative deaths among residents. Independent variables included income inequality, racial/ethnic heterogeneity, and percent immigrants in the ½ mile buffer around facilities.

Results. Facilities with more Black or Latino residents experienced more Covid-19 cases (IRR = 1.005; 1.004) and deaths (IRR = 1.008) among residents, staff and facility personnel during the first six months of the pandemic, but were no different after 12 months. Facilities with more racial/ethnic heterogeneity and percent Black or Latino in the surrounding buffer experienced more Covid-19 cases and deaths in the first six months, but no such differences were observed in the subsequent 24 months. Facilities surrounded by higher percent Latino in the surrounding buffer consistently experienced more cases among staff and facility personnel over the entire time period (IRR = 1.006; 1.001).

Conclusions. Findings indicated a pattern of socio-spatial health disparities among residents, staff, and facility personnel in the first six months of the pandemic. However, there was evidence of some of the observed disparities fading during the subsequent months of the pandemic, which likely suggests the importance of the adoption and adherence to pandemic related safety measures in skilled nursing facilities nationwide, in spite of the socio-spatial characteristics of the areas surrounding these facilities.

Keywords: socio-spatial; health disparities; Covid -19, neighborhoods.

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Introduction

The disproportionate vulnerability of elderly in long-term care facilities to respiratory illnesses such as influenza and other common human coronaviruses is well documented [1,2]. Reasons for the unique fragility of this elderly population for the transmission of respiratory diseases, notably Coronavirus Disease 19 (i.e., Covid-19), include multiple concurrent underlying health conditions, personnel working in multiple facilities, the lack of proper infection control and enforcement, and the lack of personal protective equipment among staff and facility personnel [3,4]. Skilled nursing facilities are among the highest risk settings for the transmission of Covid-19 among elderly populations and the staff and facility personnel.

The vulnerability of elderly populations housed in skilled nursing facilities to Covid-19 transmission is likely impacted by the social conditions in the geographic areas surrounding these facilities. Social disparities in Covid-19 transmission have manifested in various ways around the United States, with surging infection rates in lower income neighborhoods with high proportions of minority residents including African American, Latino, immigrant, with Native American communities bearing a disproportionate burden of the pandemic [5]. Such communities face impacts due to residential segregation and income inequality, which have exacerbated disease transmission [6,7].

The early stage of the Covid-19 pandemic had dire consequences for skilled nursing facilities, with some suffering critical disparities in Covid-19 case counts. To highlight one poignant example, the rising number of Covid-19 related fatalities in California skilled nursing facilities prompted emergency aid from the California National Guard [8], with many of these

facilities situated in low income areas. In order to gain insight into the social conditions surrounding skilled nursing facilities in the U.S. which likely impacted Covid-19 transmission within facilities, the current study examines whether the number of cases reported among residents, staff, and facility personnel and deaths among residents relate to *socio-spatial* health disparities present in the areas surrounding these facilities. We define socio-spatial disparities as place-based racial, ethnic, and socioeconomic disparities in health status disproportionately experienced by low income and minority populations. Premised upon the longstanding and robust epidemiological evidence indicating a social gradient in health, [9] we posit that skilled nursing facilities located in impoverished areas with high proportions of minority populations and residential segregation by race, ethnicity and socioeconomic status will display relatively higher rates of Covid-19 cases among residents, staff and facility personnel.

To accomplish this goal, we utilized a novel spatial approach [10] to identify precise geographic areas surrounding all nursing facilities across the U.S. to examine relationships between the socio-spatial context surrounding each skilled nursing facility and the number of Covid-19 cases reported among residents, staff and facility personnel, and the number of deaths among residents. We examine how the number of cases and deaths changed over the first 30 months of the pandemic in order to also observe the effect of the vaccines, which were first administered in the US in mid-December 2020.

Data and Methods

Data

Data for the present study come from several sources. Information on the number of Covid-19 cases reported for 12,403 nursing homes in the U.S. comes from the Nursing Home COVID-19 Public File, which includes data reported by nursing facilities to the CDC's National

Healthcare Safety Network (NHSN) system.[1] We use data from the last week of each month beginning in June 2020 until September 2022. Geographic information on the latitude and longitude of these facilities and demographic information on the residents and staff and facility personnel comes from the LTCFocus dataset from Brown University.[2] These two files were merged based on the Federal provider number of each facility. After placing these facilities in census blocks, we merged data from the U.S. Census in 2010 and the American Community Survey 2012 5-year estimates.

Dependent Variables

The first two dependent variables were the cumulative number of reported laboratory positive Covid-19 cases in the skilled nursing facilities reported to the CDC up to the particular time point among 1) residents and 2) staff and facility personnel. Staff and facility personnel include anyone working or volunteering at the facility, including but not limited to contractors, temporary staff, resident care givers and shared staff. For brevity, we refer to this measure as "staff" rather than "staff and facility personnel" below. The third dependent variable was a count of deaths among residents only, as there were too few deaths among staff for statistical analyses.

Facility-level independent variables

We accounted for key characteristics of the nursing facility that might explain the level of Covid-19 cases observed there. We included a measure of the *number of beds* in the facility, log transformed. We computed the percent of residents admitted on: 1) *Medicaid* (income-based); 2) *Medicare* (generally age-based), with all other categories as the remainder. We computed the *average age of residents*, and the racial/ethnic composition of residents with *percent Black* and *percent Latino*. We created measures of *resident health acuity* and *nursing capacity* as factor

[1] https://data.cms.gov/stories/s/COVID-19-Nursing-Home-Data/bkwz-xpvg
[2] https://ltcfocus.org/

scores from Principal Components analyses (Cronbach's alpha = .89 and .76, respectively). The resident health acuity measure combines four items: 1) Acuity Index of overall care needed; 2) Nursing case mix index; 3) Resource Utilization Group Nursing Case Mix Index; 4) Average Activities of Daily living index. The nursing capacity measure combines four items: 1) the number registered nurse (RN) FTEs divided by the sum of RN FTEs and licensed practical nurse (LPN) FTEs; 2) RNs per capita; 3) LPNs per capita; 4) certified nursing assistants (CNAs) per capita.

Socio-spatial variables

We accounted for the spatial context around these skilled nursing facilities. Rather than placing these facilities into the census tract in which they are located, which is less ideal given the variability of tract sizes and the possibility that a facility may be located near the edge of a tract, we precisely measured a geographically defined buffer around the facility and computed the demographic context within this area. This strategy is similar to other work measuring the area around a block as a buffer [11,12] or as an egohood [10]. We construct the egohood measures by aggregating the data for the block with the facility, and all blocks whose centroids are within ½ mile of the focal block, and computing the measure of interest.[3]

We constructed several key socio-spatial variables capturing the local ½ mile context surrounding a facility within these buffer areas. We measured the racial/ethnic composition with measures of *percent Black*, *percent Latino,* and *percent Asian* (with percent White and other race as the remainder), and we computed the *percent immigrants*. Racial mixing is captured with *racial/ethnic heterogeneity*, which is a Herfindahl Index of the five racial/ethnic groups; with

[3] There were extremely few facilities in the same block, and only a small percentage in overlapping egohoods. The egohoods are unique measures, and therefore do not create nesting even when overlapping. However, we estimated our models allowing for clustered standard errors based on tracts (similar size to our egohoods), and the results were extremely similar.

five categories, this variable ranges from zero to .8 with higher values indicating more racial heterogeneity. The Herfindahl index has an intuitive interpretation in capturing the probability of randomly encountering someone of a different race/ethnicity, thus a value of .33 indicates that one would randomly encounter 33% people of a different race/ethnicity and 67% of the same race/ethnicity in the egohood. We computed the *population* (log transformed), which is effectively population density given that the buffers are a constant areal size. Socio-economic status is captured with *average household income*, and *income inequality* was measured as the standard deviation of logged income.

In ancillary models we assessed whether vaccination rates in facilities impacted our results. During 2021 we constructed measures of the percentage of residents who are vaccinated, and the percentage of vaccinated staff. During 2022, we constructed measures for residents or staff that were the average of: 1) percentage who have received a vaccine; 2) percentage who have received a booster vaccine.

Methods

Given that the outcome variables are counts of the number of Covid-19 cases or deaths in each skilled nursing facility, we employed state-level fixed effects negative binomial regression models to account for the overdispersed nature of the count data, estimated in Stata 15.1 with the nbreg command. The overdispersion indicates that the variance is greater than the mean (violating the assumption of a Poisson distribution) and can be visually seen in Figure A1 in the Supplemental Materials. For our primary analyses, we estimated models based on the number of cases in five six-month periods: 1) March 2020-September 2020; 2) October 2020-March 2021; 3) April 2021-September 2021; 4) October 2021-March 2022; 5) April 2022-September 2022. We present the results of these models in the supplementary document. Given that the results in

periods 2-5 were extremely similar, we combined these four periods into one set of analyses in the manuscript. Finally, we also estimated cumulative models separately for each month in the first year of the pandemic, and present the coefficient estimates from each of the months in Figures.

It was determined by the Institutional Review Board at UC Irvine that this study did not constitute human subject research and therefore IRB review was not required.

Results

The summary statistics for the variables used in the analyses are presented in Table 1 for the 12,403 nursing facilities in the analyses. About 60% of the residents residing in these facilities were on Medicaid, and 14% were on Medicare. The average age is 79.4, 13% are Black and 7% are Latino. Compared to the residents of the facilities, there are slightly fewer Blacks, on average, in the neighborhoods surrounding these facilities (11.5%), but more Latinos (11.6%). These communities are nearly 12% immigrants, on average. In Figure 1 we plot the three-month moving average of the mean number of cases and deaths for residents and staff over the study period. We see a spike in the number of cases during the two winter periods, and a smaller peak in summer 2022, though there is little evidence of a spike in resident deaths in winter 2022. By December 2022, the facilities in the study had experienced 95.1 resident cases, on average, 97.9 staff cases, and 10.7 resident deaths.

<<<Table 1 about here>>>

<<<Figure 1 about here>>>

Number of cases and deaths among residents

We begin with the results for cases and deaths among residents, and report the incident rate ratios (IRR), which can be interpreted as showing the percentage change in the outcome

variable. As seen in Table 2, model 1, facilities with more beds experienced disproportionately more resident cases per capita (IRR = 3.681, 95% CI = 3.418-3.965). Given that this measure is logged, IRR values greater than 2.718 (a raw coefficient of 1) indicate that larger facilities experience relatively more resident cases per capita. However, after the first six months, cases are disproportionately more likely to occur in smaller facilities given that the IRR is less than 1 (column 2, IRR = 2.407, 95% CI = 2.351-2.463). The pattern is quite similar for resident deaths (columns 3 and 4). Also, a ten percentage point increase in Medicare residents was associated with 7.5% more cases for residents (IRR = exp(.0072*10)=1.075), and a similar increase in Medicaid residents was associated with 3.4% more resident cases in the first six months, and 1.4% more since then. Facilities with more Medicare residents experienced more deaths in the first six months (column 3), but not since then (column 4). Facilities with an increase of ten years in average age of residents experienced 9.7% more cases in the first six months, but there was no difference after that. However, facilities with older residents have consistently experienced more deaths over the entire pandemic (columns 3 and 4). In the first six months, a ten percentage point increase in Black residents was associated with 5.5% more cases and 8.1% more deaths for residents, and a similar increase in Latino residents was associated with 4.2% more cases and 8.1% more deaths. However, since then, facilities with more Black or Latino residents actually have relatively *fewer* cases and deaths (about 5 to 6% fewer deaths). Facilities with greater nursing capability experienced fewer cases among residents after the first six months of the pandemic.

<<<Table 2 about here>>>

The socio-spatial measures also showed changes over time. In the first six months, facilities surrounded by a higher percentage of Black residents had more deaths; however, since

then such facilities have fewer cases (IRR = .997) and deaths (IRR = .996). Whereas facilities surrounded by ten percentage points more Latino residents experienced 8.2% more cases and 6.8% more deaths in the first six months, since then there is no difference. Facilities surrounded by a higher percentage of Asians had fewer deaths in the first six months but they experienced more cases since then. In the first six months of the pandemic, facilities surrounded by higher racial/ethnic heterogeneity (a 0.1 increase) experienced 4.7% more cases and 7.5% more deaths, but not since then. Facilities surrounded by ten percentage points more immigrants had 7.5% more resident deaths in the first six months, but 10% fewer deaths since then. In the first six months, facilities surrounded by 10% higher average income experienced 2.9% more resident cases and 4.4% more deaths, but since then they experienced 1.8% fewer cases and 3.1% fewer deaths. After the first six months, facilities surrounded by more income inequality (.1 on the scale) had 3% fewer resident cases and 4.6% fewer deaths and those surrounded by greater population density had fewer cases and deaths.

Number of cases among staff and facility personnel

The models with the number of cases among staff and facility personnel as the outcome variable in columns 5 and 6 of Table 2 almost all show a different relationship over time. After the first six months of the pandemic, in larger facilities staff experienced fewer cases (IRR = 2.094, 95% CI = 2.057-2.132). Facilities with more Black, Latino, Medicare and older residents, and those surrounded by more Latino and Black residents and more racial/ethnic heterogeneity, experienced more cases among staff in the first six months, but not since then.[4] Whereas facilities with higher average income in the surrounding area experienced more staff cases in the first six months, this flipped to a negative relationship since then. After the first six months,

[4] Only percent Latino in the surrounding area remained positive after the first six months, although with a much smaller coefficient.

facilities surrounded by higher levels of income inequality, population density, or immigrants have modestly fewer cases reported among staff.

Monthly models

To assess when these changes occurred we estimated monthly cumulative models over the first 12 months and report the coefficients for cases in Figure 2 (and the remainder in Figures A2-A7 in the Supplemental document). In Figure 2, the top left plot in this figure shows the coefficient values (and 95% confidence interval) for the logged number of beds variable, and the strong positive relationship near 1.4 in July 2020, shows a steady decline over the subsequent months. By the end of the year it has reached a new equilibrium, which it has maintained since then. These plots show approximately when these coefficients changed for cases or deaths: for percent Black in the facility it was June 2020, for percent Latinos it was October 2020, for facilities surrounded by more racial/ethnic heterogeneity it was August 2020, and for facilities surrounded more immigrants it was June 2020. For resident deaths the peaks for percent Black or Latino in the surrounding area are August 2020.

<<<Figure 2 about here>>>

Ancillary models

To assess whether Covid-19 vaccine availability after January 2021 altered our findings, we estimated ancillary models that added the vaccination rates of residents and staff (and the quadratic versions) in these facilities during this later timeframe to our earlier models.[5] The general pattern of our results remained unchanged. There was, however, evidence of the vaccine's efficacy, as shown in Figures 3-5. We split the data into 6-month periods beginning

[5] During 2021 we constructed measures of the percentage of residents who are vaccinated, and the percentage of staff. During 2022, we constructed measures for residents or staff that were the average of: 1) percentage who have received a vaccine; 2) percentage who have received a booster vaccine.

with vaccine availability, and in most time periods we found a nonlinear relationship between the percentage vaccinated and either cases or deaths (captured with quadratic versions of the vaccination variables). The x-axis of these graphs plots the percentage vaccinated in the facility from the 5th to the 95th percentile, and we scale the IRR of the Y-axis to compare to a facility at the 5th percentile of the vaccination rate. For example, in Figure 3a, a facility at the 5th percentile had a 52% resident vaccination rate at the end of the January-June 2021 period, whereas a facility at the 95th percentile had a 98% resident vaccination rate, and the value of .76 on the y-axis indicates the IRR, showing that resident cases are 24% lower in the latter facility compared to the former. From July-December 2021, there were about 40% fewer cases in a high vaccination facility compared to a low vaccination one. This nonlinear relationship between resident vaccination rate and resident cases in facilities was present in 2022 also (measured as a combination of any vaccination, and a booster vaccination). There is also evidence since July 2021 that facilities with a higher vaccination rate among staff have fewer cases among residents (Figures 3f-3h). There is strong evidence that facilities with higher vaccination rates among residents have lower death rates (Figures 4a-4d), and higher vaccination rates among staff were related to lower death rates from July-December 2021 (Figure 4f). Finally, facilities with higher vaccination rates among staff have fewer staff cases (Figures 5e-5h).

<<<Figures 3 to 5 about here>>>

Discussion

Our findings indicate a discernable pattern of socio-spatial health disparities in Covid-19 cases among residents, staff, and facility personnel in the skilled nursing facilities under study during the first six months of the pandemic: place-based race, ethnicity, immigrant status, and socioeconomic factors were related to higher levels of cases among residents and staff. We also

observed a similar pattern of disparities for resident deaths: facilities with more Medicaid patients and higher average age experienced more resident deaths throughout the study period, and those with more Medicare patients and a higher percent Black experienced more resident deaths in the first six months of the pandemic. Facilities with a higher percent Latino residents generally experienced more resident deaths. Even when controlling for the age of the residents in the facilities, those with more Latino or Black residents still reported more cases of Covid-19, for both residents and staff alike in the first half-year of the pandemic. Moreover, skilled nursing facilities surrounded by areas with high proportions of immigrant populations tended to experience more cases for residents, staff. In addition, facilities surrounded by areas with higher levels of racial/ethnic mixing tended to experience more cases for residents and staff. However, equally notable was how many of these patterns changed over the following two years. In what follows, we highlight three key themes of our findings.

First, we found some evidence of consistent disproportionality in which types of facilities were more likely to experience cases and deaths among residents. Specifically, facilities with older residents, more Medicaid or Medicare residents generally experienced more cases and deaths among residents throughout the study period. These were expected results for older residents given their fragility and thus higher risk for Covid-19 transmission. The presence of Medicaid residents is a proxy for economic disadvantage, and their greater risk could be due to poorer quality care received in such facilities, or because of a lack of financial and other familial resources that might mitigate their risk. These findings corroborate past studies indicating social disparities in nursing facility quality of care in areas with low income and minority populations. In a cross-sectional study examining nursing facilities in US metropolitan areas, those serving largely low-income and racial minority residents or those situated in neighborhoods with higher

proportions of low-income and racial minority populations displayed worse financial outcomes and quality of care relative to those in higher income neighborhoods with more dispersed populations [13]. Moreover, this study also indicated that being on Medicaid related to higher fiscal stress and lower quality of care in a nursing facility. In addition, other studies indicate that residing in socioeconomically disadvantaged counties negatively relates to nursing home staffing and quality ratings [14].

Secondly, we found evidence of race and ethnicity-based health disparities in Covid-19 cases and deaths that differed between the first six months of the pandemic and thereafter. During the first six months, facilities with more Black and Latino residents, and those surrounded by neighborhoods with a higher percent Black residents, higher percent immigrant residents, and more racial/ethnic heterogeneity experienced more cases and deaths. These findings are consistent with the disproportionate burden in Covid-19 cases occurring among racial and ethnic minority groups nationwide. Our findings also corroborate studies indicating that Blacks suffer a disproportionate burden relative to their population size, as while they constitute approximately 13% of the US population, they comprised 34% of the total mortality due to Covid-19 across nine US states in the Midwest, Southeast, Northeast, Mid-Atlantic [15]. Moreover, other studies indicated that long standing systemic health and social inequalities render racial and ethnic minority groups at higher risk of contracting Covid-19 or of having a severe illness, irrespective of age [16]. Our findings also are consistent with research indicating that non-Hispanic black persons, Hispanics/Latinos, and American Indians/Alaska Natives, experience higher rates of hospitalization or death from COVID-19 in comparison to non-Hispanic whites [16]. However, it was striking to note that our findings indicating relationships displaying race and ethnicity-based health disparities in Covid-19 cases and deaths disappeared

by the end of the first year of the pandemic for some groups. One speculative explanation for these relationships disappearing is that these changes may have coincided with the implementation of infection control procedures, including Covid-19 testing protocols, put into place in these facilities.

Our results showed strong changes in the patterns of cases and deaths before the end of 2020, when the first vaccines became available —indicating that vaccines cannot explain these changes in disproportionate vulnerability—our ancillary findings nonetheless indicated that vaccines appeared to play a major role in decreasing cases among residents and staff, and deaths among residents. At higher levels of resident vaccine coverage we observed notably fewer resident cases. At higher levels of staff vaccine coverage, we also observed notable decreases in resident cases, especially from July through December 2021. In general, we observed non-linear effects in which higher levels of staff vaccination coverage were most beneficial for resident cases. Furthermore, high resident vaccination rates had a very strong negative relationship with resident deaths, underscoring the importance of continuing to support policy and public health efforts to vaccinate residents.

At higher levels of staff vaccination coverage, we observed generally lower levels of residence deaths, especially during the period of July through December 2021. It is notable that our findings suggest that a relatively high percentage of staff vaccination rates is necessary to have a protective effect on the percentage of resident deaths. This finding indicates that staff in nursing homes need to be up to date and adherent regarding current Covid-19 vaccine protocols, even in the face of diminishing rates of vaccine uptake among this population in the US. These findings also point to a need to educate staff about the risks of not following vaccine protocols and mandates per state regulations. One surprising finding was that a higher resident vaccination

rate was associated with more cases among staff, particularly in 2022. We are not sure why this occurred, but one speculation is that a high resident vaccination rate—if staff are aware of it—may have led to less adherence to staff and facility personnel's own vaccination, mask wearing and other infection control behaviors. Nonetheless, cases among staff were precipitously lower at high levels of staff vaccines, highlighting the importance of vaccines for keeping staff infections down.

Our findings are consistent with other studies indicating that staff vaccination coverage is a major factor in the prevention of nursing home resident cases and deaths. One study of US nursing homes found that in high Covid-19 prevalence counties higher staff vaccination rates were associated with fewer resident cases and deaths [17]. A cohort study found that prior to the Omicron variant, higher staff vaccination rates were associated with lower incidence of Covid-19 cases and deaths among residents and staff; however, as new variants surfaced, the Covid-19 vaccine made available in December 2020 was no longer associated with lower rates of adverse Covid-19 outcomes, highlighting the need for policy changes that encourage the uptake of booster doses among nursing home staff [18].

Moreover, we found that facilities located in higher income neighborhoods experienced more cases and deaths in the first six months of the pandemic, and this effect completely reversed thereafter. Whereas there was no evidence that facilities with better nursing capability had lower cases or deaths in the first six months of the pandemic, these facilities had lower case and death rates since then. Perhaps the implementation and enforcement of infection control strategies in facilities decreased transmission over time, and these measures were more likely implemented in facilities with more and higher credentialed nursing. We also observed that larger facilities were disproportionately impacted by cases and deaths in the early part of the

pandemic, with a reversal in this effect thereafter. That larger facilities could potentially be impacted by large outbreaks early in the pandemic and this effect reversed thereafter may imply that the implementation of infection control procedures would allow these facilities to do relatively better later in the pandemic. Nonetheless, all of this needs to be the focus of future research.

Public Health Implications. Our findings highlight the importance of examining racial, ethnic, and socioeconomic characteristics of the precise spatial areas surrounding skilled nursing facilities to offer insights into why health disparities in Covid-19 cases occur differentially among residents, staff, and facility personnel in certain areas or during certain time periods. Future studies should identify mechanisms through which Covid-19 transmission occurs in the spatial areas around these facilities which can affect transmission inside these facilities. Contextual factors characteristics of the areas surrounding these facilities may act to increase or decrease the risk of infection inside skilled nursing facilities, and as such, interactions between the characteristics of the surrounding context and the characteristics within these facilities that place residents, staff and facility personnel at increased risk for Covid-19 transmission should be examined in future studies. Moreover, our study underscores the importance of targeting geographic areas with skilled nursing facilities which are in the most need of resources to mitigate Covid-19 transmission.

This study also suggests the major importance and efficacy of vaccines in decreasing the number of cases and deaths among staff and facility personnel and residents. Our findings also suggest the importance of continued adherence to Covid-19 current vaccination protocols for residents, staff and facility personnel.

Limitations. This study has limitations, including that it focused on skilled nursing facilities and does not examine assisted living facilities and other congregate living settings. Moreover, we did not measure mechanisms through which the context surrounding these facilities related to the cases and deaths, so we cannot say why these differences occurred, nor why they changed over time during the first year of the pandemic. Lastly, our study lacked longitudinal data of our independent variables, and therefore does not allow understanding the directionality of relationships.

Conclusion. The present study examined the relationship between socio-spatial characteristics of areas surrounding U.S. skilled nursing facilities and Covid-19 cases reported among residents, staff and facility personnel. Our findings indicated a distinctive pattern of socio-spatial health disparities in Covid-19 cases and deaths occurring among residents, staff and facility personnel in the first six months of the pandemic, likely highlighting structural disadvantage present in some facilities and the locales surrounding them. More research is necessary to identify and disentangle the unique factors operating within the spatial areas surrounding these facilities and the factors operating inside these facilities to illuminate why some facilities experienced a disproportionately high burden of Covid-19 cases among these exceedingly fragile and voiceless elderly population, particularly during the early stages of the pandemic.

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Tables and Figures

Table 1. Summary statistics of variables included in analyses. N = 12,403 skilled care nursing facilities

	Mean	S.D.	Min	Max
Skilled nursing facility variables				
Number of beds	112.5	60.8	12.0	874.0
Percent Medicaid patients	59.9	22.5	0.0	100.0
Percent Medicare patients	13.7	12.3	0.0	100.0
Average age (years)	79.4	7.1	4.0	93.6
Percent Black	13.2	18.5	0.0	100.0
Percent Latino	6.8	12.7	0.0	100.0
Average acuity level	0.0	1.0	-5.5	10.6
Nursing capability	0.0	0.9	-2.6	16.9
Socio-spatial variables				
Percent Black	11.4	18.8	0.0	100.0
Percent Latino	11.7	17.2	0.0	98.5
Percent Asian	3.5	6.9	0.0	80.5
Racial/ethnic heterogeneity	0.33	0.20	0.00	0.78
Percent immigrants	11.6	11.4	0.0	81.4
Average income (logged)	3.75	0.36	2.35	5.20
Income inequality	0.90	0.09	0.49	1.36
Population (1000s)	2.98	5.02	0.00	109.97

Note: Resident health acuity is a factor score from a Principal Components analysis of four items: 1) Acuity Index of overall care needed; 2) Nursing case mix index; 3) Resource Utilization Group Nursing Case Mix Index; 4) Average Activities of Daily living index

Note: Nursing capacity is a factor score based on a Principal Components analysis of four measures: 1) the number registered nurse (RN) FTEs divided by the sum of RN FTEs and licensed practical nurse (LPN) FTEs; 2) RNs per capita; 3) LPNs per capita; 4) certified nursing assistants (CNAs) per capita

Note: Racial/ethnic heterogeneity is 1 - sum of squares of proportion White, Black, Asian, Latino, and other race.

Note: Income inequality is the standard deviation of logged household income

Table 2. Incident rate ratios from negative binomial regression models predicting the number of Covid19 cases in U.S. skilled nursing facilities among residents and staff & facility personnel. N = 12,403 skilled nursing facilities.

	(1)		(2)		(3)		(4)		(5)		(6)	
	Cases reported among residents				Deaths reported among residents				Cases reported among staff & facility personnel			
	March 2020 - Sep 2020		Oct 2020 - Sep 2022		March 2020 - Sep 2020		Oct 2020 - Sep 2022		March 2020 - Sep 2020		Oct 2020 - Sep 2022	
Number of beds, logged	3.681	**	2.407	**	3.784	**	2.436	**	2.660	**	2.094	**
	3.418	3.965	2.351	2.463	3.473	4.122	2.327	2.549	2.547	2.778	2.057	2.132
Percent medicaid patients	1.003	**	1.001	**	1.002	†	1.001	†	0.998	**	0.998	**
	1.001	1.005	1.001	1.002	1.000	1.004	1.000	1.002	0.997	0.999	0.997	0.998
Percent medicare patients	1.007	**	1.007	**	1.005	**	1.001		1.003	**	1.000	
	1.004	1.010	1.006	1.008	1.002	1.009	0.999	1.003	1.001	1.004	0.999	1.001
Average age (years)	1.009	**	1.000		1.028	**	1.027	**	1.008	**	1.000	
	1.003	1.016	0.999	1.002	1.021	1.036	1.023	1.031	1.004	1.011	0.999	1.002
Percent Black	1.005	**	0.998	**	1.008	**	0.994	**	1.003	**	0.995	**
	1.003	1.008	0.997	0.999	1.004	1.011	0.992	0.995	1.001	1.005	0.994	0.996
Percent Latino	1.004	*	0.999		1.008	**	0.995	**	1.003	**	0.997	**
	1.000	1.008	0.998	1.001	1.003	1.012	0.992	0.997	1.001	1.006	0.996	0.998
Average acuity level	1.013		0.989	†	1.035		1.019		1.032	**	1.037	**
	0.970	1.057	0.976	1.001	0.985	1.087	0.992	1.046	1.008	1.056	1.028	1.046
Nursing capability	0.967	†	0.958	**	0.985		0.979	†	1.066	**	1.124	**
	0.933	1.002	0.946	0.969	0.944	1.027	0.955	1.003	1.041	1.093	1.113	1.136

Socio-spatial variables (1/2 mile egohoods)																
Percent Black	1.002			0.997	**		1.004	*		0.996	**		1.002	*		1.000	
	0.999	1.005		0.996	0.998		1.001	1.007		0.995	0.998		1.000	1.004		0.999	1.000
Percent Latino	1.008	**		1.000			1.007	**		1.002			1.006	**		1.001	*
	1.004	1.012		0.999	1.001		1.002	1.011		0.999	1.004		1.004	1.009		1.000	1.002
Percent Asian	0.996			1.001			0.991	*		1.008	**		0.998			1.002	
	0.989	1.004		0.999	1.003		0.982	0.999		1.003	1.013		0.993	1.003		1.000	1.003
Racial/ethnic heterogeneity	1.584	**		1.034			2.053	**		0.951			1.327	**		0.885	**
	1.255	1.998		0.959	1.114		1.583	2.663		0.820	1.103		1.151	1.530		0.834	0.940
Percent immigrants	1.001			0.996	**		1.007	*		0.990	**		1.002			0.996	**
	0.995	1.007		0.995	0.998		1.001	1.014		0.986	0.993		0.998	1.006		0.994	0.997
Average income (logged)	1.326	**		0.838	**		1.557	**		0.733	**		1.273	**		0.825	**
	1.179	1.491		0.807	0.870		1.362	1.781		0.680	0.789		1.186	1.367		0.800	0.850
Income inequality	1.064			0.732	**		0.909			0.624	**		1.069			0.819	**
	0.734	1.541		0.652	0.823		0.597	1.385		0.496	0.784		0.856	1.335		0.746	0.899
Population (1000s)	0.995			0.993	**		0.997			0.986	**		0.999			0.997	**
	0.987	1.003		0.991	0.996		0.989	1.006		0.981	0.991		0.995	1.004		0.995	0.999
Intercept	0.006	**		2.844	**		0.000	**		0.069	**		0.048	**		9.124	**
	0.002	0.014		2.142	3.775		0.000	0.000		0.039	0.124		0.029	0.082		7.338	11.34
Pseudo r-square	0.030			0.051			0.045			0.036			0.049			0.057	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .10 (two-tail test). Top number is IRR estimate, with 95% confidence interval below. Color coding: green highlighted cells are positively significant at p < .05; red highlighted cells are negatively significant at p < .05*

Figure 1. Mean number of cases and deaths per facility reported in residents or staff & facility personnel from June 2020 to December 2022 (3-month moving average)

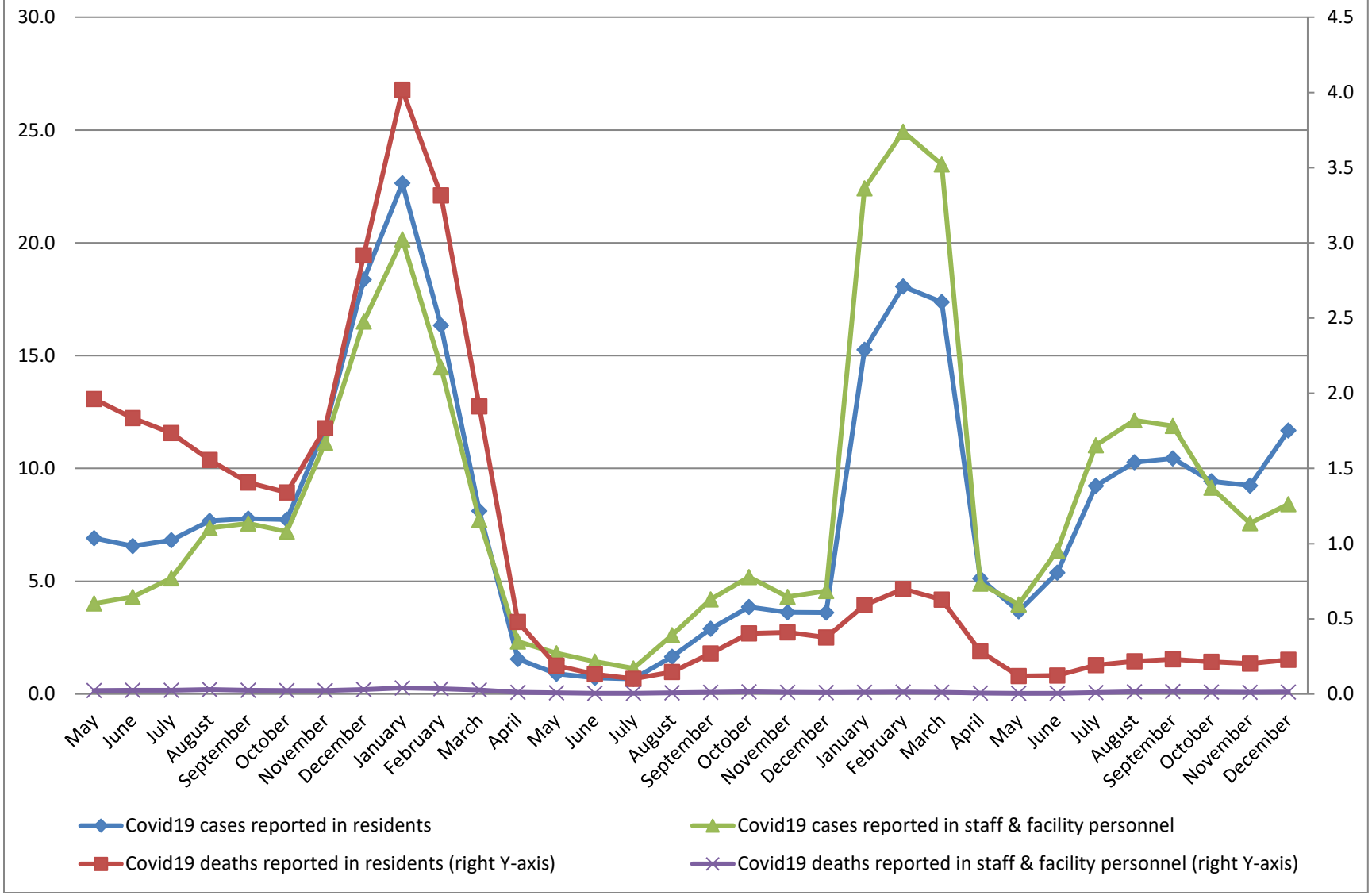

Figure 2. Coefficients for resident cases

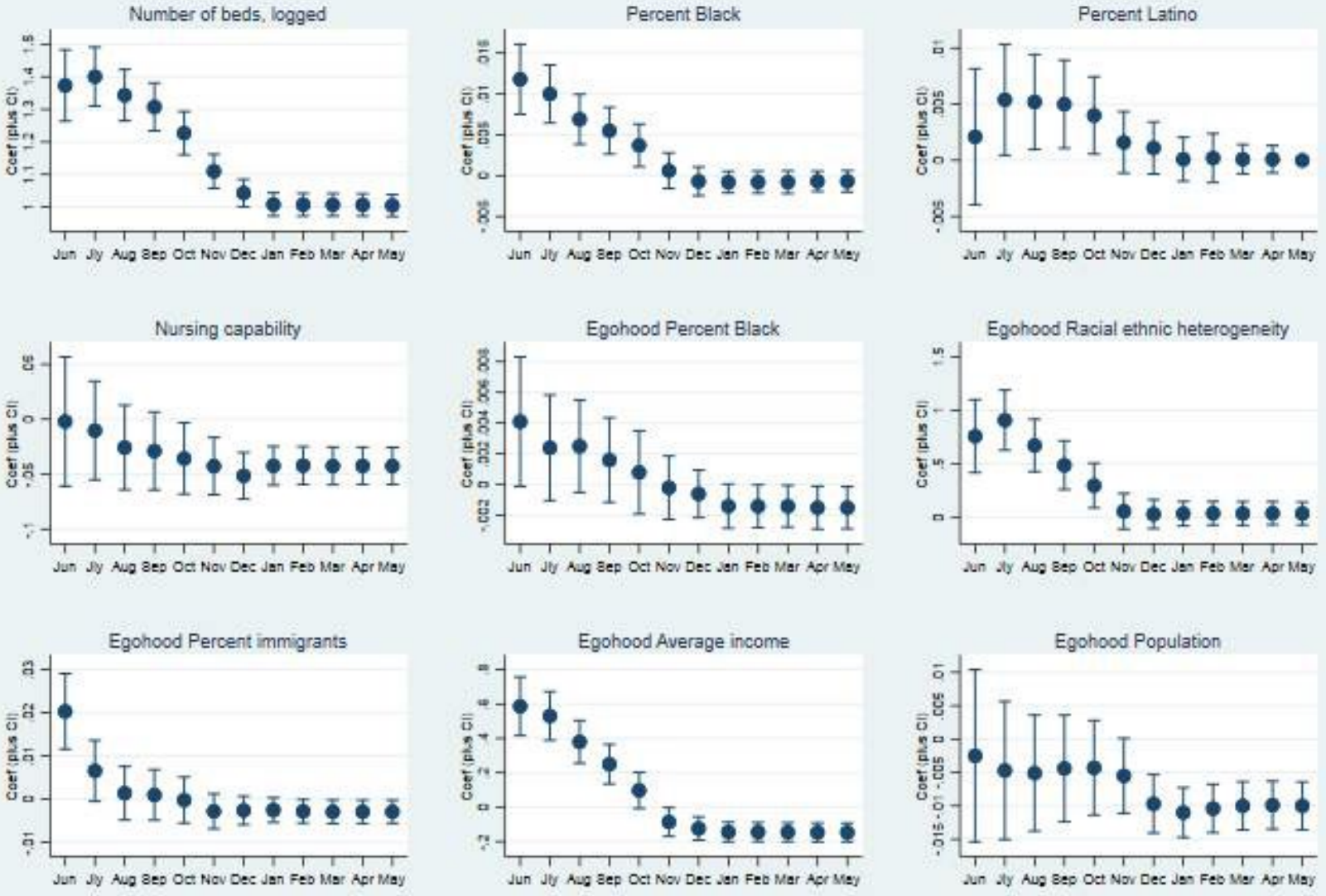

Figure 3. IRR values for resident cases based on resident or staff and facility personnel vaccination rate from 5th to 95th percentile, across four 6-month periods

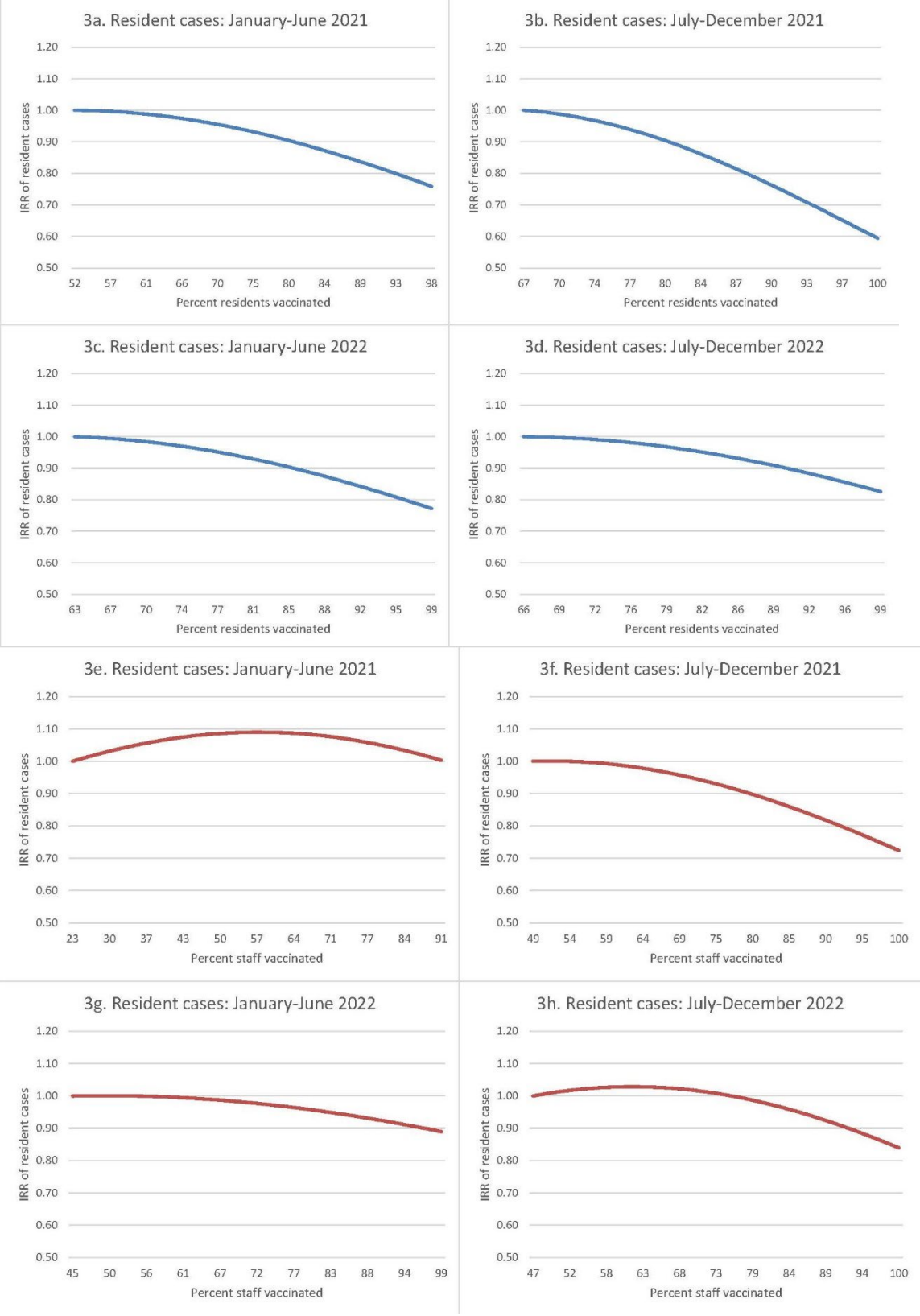

Figure 4. IRR values for resident deaths based on resident or staff and facility personnel vaccination rate from 5th to 95th percentile, across four 6-month periods

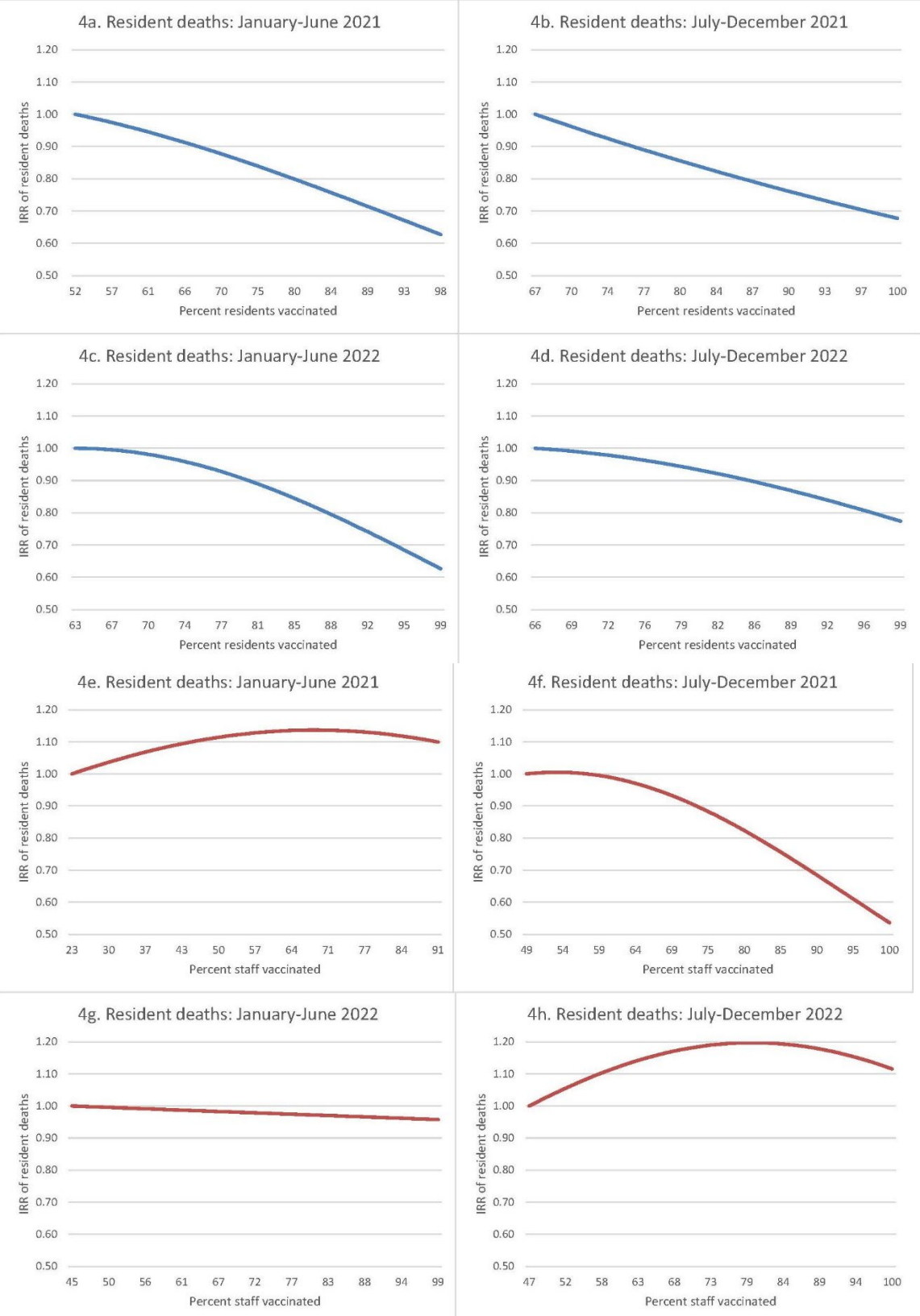

Figure 5. IRR values for staff cases based on resident or staff and facility personnel vaccination rate from 5th to 95th percentile, across four 6-month periods