


Short-term impact of nursing home SARS-CoV-2 vaccinations on new infections, hospitalizations, and deaths

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Abstract

Objective: To compare rates of incident SARS-CoV-2 infection and 30-day hospitalization or death among residents with confirmed infection in nursing homes with earlier versus later SARS-CoV-2 vaccine clinics.

Design: Matched pairs analysis of nursing homes that had their initial vaccine clinics between December 18, 2020, and January 2, 2021, versus between January 3, 2021, and January 18, 2021. Matched facilities had their initial vaccine clinics between 12 and 16 days apart.

Setting and Participants: Two hundred and eighty nursing homes in 21 states owned and operated by the largest long-term care provider in the United States.

Measurements: Incident SARS-CoV-2 infections per 100 at-risk residents per week; hospital transfers and/or deaths per 100 residents with confirmed SARS-CoV-2 infection per day, averaged over a week.

Results: The early vaccinated group included 136 facilities with 12,157 residents; the late vaccinated group included 144 facilities with 13,221 residents. After 1 week, early vaccinated facilities had a predicted 2.5 fewer incident SARS-CoV-2 infections per 100 at-risk residents per week (95% CI: 1.2–4.0) compared with what would have been expected based on the experience of the late vaccinated facilities. The rates remained significantly lower for several weeks. Cumulatively over 5 weeks, the predicted reduction in new infections was 5.2 cases per 100 at-risk residents (95% CI: 3.2–7.3). By 5 to 8 weeks post-vaccine clinic, early vaccinated facilities had a predicted 1.1 to 3.8 fewer hospitalizations and/or deaths per 100 infected residents per day, averaged by week than expected based on late vaccinated facilities' experience for a cumulative on average difference of 5 events per 100 infected residents per day.

Conclusions: The SARS-CoV-2 vaccines seem to have accelerated the rate of decline of incident infections, morbidity, and mortality in this large multi-state nursing home population.

KEYWORDS

death, infections, nursing home, SARS-CoV-2, vaccination

See related editorial by Ouslander et al and related articles by Moore et al, Rudolph et al, and Domi et al. in this issue.

INTRODUCTION

A recent observational study reported the BNT162b2 mRNA SARS-CoV-2 vaccine to be as effective in the general population of Israel as was seen in the original randomized trial.¹ Relative to unmatched vaccinated cases, vaccinated individuals were less likely to become infected with SARS-CoV-2, develop symptomatic illness, be hospitalized, or die, and these differences began to accrue by 2 weeks after vaccination. A similar study in the United Kingdom noted an over 75% reduction in COVID-19 hospitalizations and deaths among those vaccinated with the Pfizer-BioNTech vaccine.² Another study in the United Kingdom, the SIREN study of health care workers, also found high levels of protection from both symptomatic and asymptomatic infection. Data from both the United Kingdom and Israel report vaccine effectiveness after the first dose of the two-shot series.³

U.S. nursing homes, a setting accounting for over one-third of COVID-19 fatalities in the United States, began mass vaccinations in mid-December. Recent reports note very impressive declines in mortality among residents after the first vaccine doses that seem to run counter to the pattern in the general population.^{4,5} However, coincident and antecedent declines in case rates in the community and the nursing homes complicate simple attribution of falling mortality rates to the nursing home vaccination program. Using resident-level data from Genesis Healthcare, the largest nursing home provider in the United States, we were able to compare the rate of new resident infections as well as hospital transfers and/or deaths in facilities with early versus later vaccination clinics, adjusting for infection rates each facility experienced throughout the fall.

METHODS

Data

We relied on Genesis' electronic health record (EHR) and other clinical data for 280 nursing homes located across 21 states. Genesis has coordinated SARS-CoV-2 vaccine administration through the Pharmacy Partnership for Long-Term Care Program, which provides each nursing home with three vaccine clinics spaced over a 3-month window to administer first and second doses to residents and staff. Genesis' vaccine clinics for Dose 1 began December 18, 2020, and completed January 18, 2021. Whether individual facilities received the Moderna or Pfizer-BioNTech vaccine varied by state.

Genesis data are transmitted nightly to Brown University under a Brown IRB-approved Data Use Agreement. The EHR elements include a daily census, resident

Key Points

- One week after their initial vaccine clinics, nursing homes with earlier clinics had 2.5 fewer new SARS-CoV-2 infections per 100 at-risk residents than expected based on the experiences of matched facilities with later clinics.
- Cumulatively over 7 weeks, earlier vaccinated facilities had 5.2 fewer infections per 100 at-risk residents and 5 fewer hospitalizations and/or deaths per 100 infected residents than expected without vaccinations.

Why Does this Paper Matter?

This article provides evidence of real-world effectiveness of SARS-CoV-2 vaccinations in the vulnerable nursing home population which has borne a disproportionate share of SARS-CoV-2 morbidity and mortality. This evidence supports efforts to begin resuming family visitation and lessen other restrictions in nursing homes.

demographics, diagnoses, and immunization records. These data have been used in a number of prior publications and are both complete and valid.⁶⁻⁸ Testing data for SARS-CoV-2 are retained in a separate linked file indicating test dates and results for both polymerase chain reaction and antigen tests. For the purposes of current analyses, any test confirming SARS-CoV-2 infection for the first time, (i.e., no prior confirming result) is treated as a new infection. Throughout the period of this study, Genesis facilities underwent regular testing of residents and staff both with and without symptoms, creating the basis for ongoing population outcome monitoring for incident SARS-CoV-2 infections. In addition to the resident-level data, we also relied on a facility-level file used by Genesis to track dates of vaccine clinics and the numbers of staff and residents vaccinated at each clinic.

Statistical analysis

We partitioned nursing homes into early and late vaccination groups based on the date they had their initial (Dose 1) vaccine clinic. The early vaccinated group included 136 facilities that had their initial clinic between December 18, 2020, and January 2, 2021. The late vaccinated group included 144 facilities that had their initial clinic between January 3, 2021, and January 18, 2021.

For all facilities, we computed the 7-day moving average of new SARS-CoV-2 infections per 100 residents at risk. Residents were considered to be at risk for infection if they had no ICD-10 code for COVID-19 or test result confirming SARS-CoV-2 infection within 90 days before the reference date. We also computed a 7-day moving average of deaths and/or hospitalizations within 30 days of diagnosis per 100 residents with confirmed SARS-CoV-2 infection. The date of a resident's first positive test was used as the date of diagnosis. The reason for the composite measure is because the Genesis data were not linked to Medicare claims, and thus we may not observe all deaths that occur after hospital transfer. We plotted these measures, separately, for the early and late vaccinated groups to examine the overall unadjusted trends.

To account for possible confounding, we employed a method that was previously used to examine the effects of Bed-Hold policy in nursing homes⁹ (see Supplementary Text S1). Each early vaccinated facility was matched to a corresponding facility in the late group that started vaccinating its residents 12–16 days later. Matching was implemented using trends in the numbers of residents at risk, newly infected residents, and the average daily composite rate of 30-day hospitalizations and/or deaths per 100 infected residents in the 12 weeks before an early vaccinating group facility held its first clinic. The matched nursing homes awaiting vaccination were used to predict what the earlier vaccinated facilities' infection rate (new SARS-CoV-2 infections per 100 residents at risk) and hospitalization/death rate (30-day hospitalizations and/or deaths per 100 infected residents per day, averaged by week) would have been had the early sites not been vaccinated.

RESULTS

Table 1 summarizes baseline characteristics of residents cared for by nursing homes in the early versus late vaccination groups and shows the proportion of facilities that received the Moderna versus Pfizer-BioNTech vaccine. At baseline, facilities in the early vaccination group cared for 12,157 residents (61.2% female, 11.6% black or African American, 31.5% with prior COVID-19 diagnosis, 38.3% with dementia) whereas those in the late vaccination group cared for 13,221 residents (61.2% female, 14.9% black or African American, 36.4% with prior COVID-19 diagnosis, 39.5% with dementia). In the early vaccination group, 44 (32.4%) facilities received the Moderna vaccine and 92 (67.6%) received the Pfizer-BioNTech vaccine. In

the late vaccination group, 29 (20.1%) facilities received the Moderna vaccine and 115 (79.9%) received the Pfizer-BioNTech vaccine.

Figure 1 presents the 7-day moving averages of new SARS-CoV-2 infections per 100 residents at risk, and 30-day deaths or hospitalizations per 100 residents with confirmed infection for nursing homes in the early and late vaccination groups. The vertical lines indicate the first clinic dates for each group. As can be seen, the incident infection rates for the two groups rose precipitously during November and December began to decline in the week before the early vaccine group began vaccination, and then converged in the 2 weeks between the first clinic date of the early vaccination group and the first clinic date of the later sites. For the next 3 weeks and beyond, the early vaccination facilities have somewhat lower infection rates than do the late vaccination facilities. The 7-day moving average of deaths or hospitalizations is more volatile than the rate of new infections because there

TABLE 1 Characteristics of nursing homes and residents for the early versus late vaccinated groups

	Early vaccinated nursing homes (n = 136)	Late vaccinated nursing homes (n = 144)
Nursing homes, n (%)		
Moderna vaccine	44 (32.4)	29 (20.1)
Pfizer-BioNTech vaccine	92 (67.6)	115 (79.9)
Total residents, n	12,157	13,221
Female, n (%)	7443 (61.2)	8091 (61.2)
Race/ethnicity, n (%)		
Non-Hispanic white	9610 (79.0)	9594 (72.6)
Non-Hispanic black or African American	1414 (11.6)	1966 (14.9)
Hispanic	494 (4.1)	700 (5.3)
Other	606 (5.0)	912 (6.9)
Unknown	33 (0.3)	49 (0.4)
Alzheimer's disease and related dementias, n (%)	4653 (38.3)	5221 (39.5)
Prior COVID-19 diagnosis, n (%)	3832 (31.5)	4807 (36.4)

Notes: Resident characteristics as of December 18, 2020. Early vaccinated nursing homes had their initial vaccine clinics between December 18, 2020, and January 2, 2021. Late vaccinated facilities had their initial clinics between January 3, 2021, and January 18, 2021.

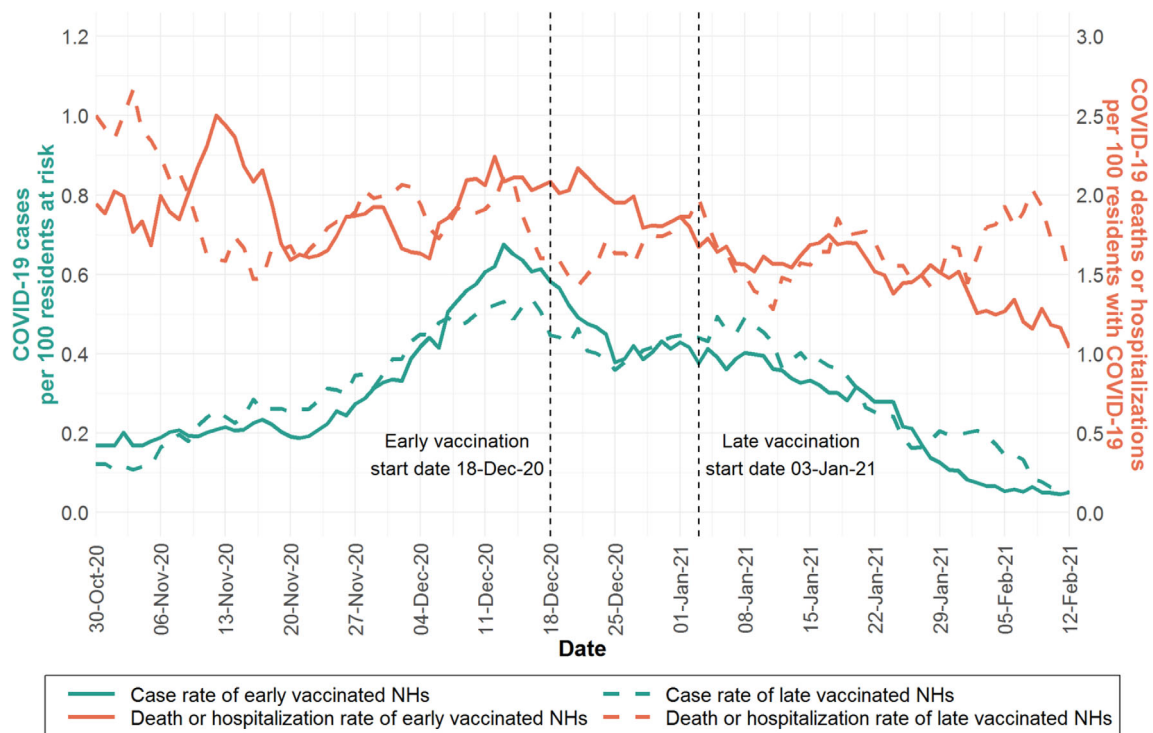


FIGURE 1 Seven-day moving average of new residents with SARS-CoV-2 infection per 100 residents at risk and 30-day deaths or hospital transfers per 100 residents with COVID-19: October 30, 2020, to February 12, 2021

are fewer events. Nonetheless, we observe that some 5 to 6 weeks after the last early vaccination facilities held clinics, their composite hospitalization or death rate drops and remains below that of the late vaccination facilities.

Table 2 presents the model-based estimates of the differences between the early versus later vaccinated facilities along with their 95% credible intervals (CI) for incident infections per 100 residents at risk, and hospitalization or death per 100 infected residents per day, averaged by week. A statistically significant reduction in incident infections is observed as early as the first week after the start of vaccinations in the early facilities. The model predicts 1.6 (95% CI: 0.2–3.2) and 2.5 (95% CI: 1.2–4) fewer incident infections per 100 at-risk residents in the first and second weeks after vaccine clinic, respectively than would have been expected based upon the experiences of the late vaccination facilities. Although the level of statistical significance varies, the next 5 weeks follow a similar trend of lower infection rates than would have been predicted, creating a cumulative reduction of 5.2 cases per 100 at-risk residents (95% CI: 3.2–7.3).

For the composite outcome of hospitalization and/or death among residents with new SARS-CoV-2 infection in the prior 30 days, we observe a small non-

significant increase (<1 event per 100 infected residents per day on average) in early versus late vaccinating facilities in the 4 weeks after the initial clinic. This likely reflects the fact that this rate includes both vaccinated and unvaccinated residents because individuals with active COVID-19 are excluded from the vaccination program until after acute illness resolves. Nonetheless, by weeks 5 to 7, sometime after the last facility in the early vaccine group held its initial clinic, the early nursing homes had a predicted 1.1 to 3.8 fewer hospitalizations and/or deaths per 100 infected residents per day, averaged by week than expected based on the late vaccination facilities, representing an on average cumulative rate difference of some 5 events per 100 infected residents per day.

DISCUSSION

In this study of the impact of SARS-CoV-2 vaccination on nursing home residents, we found that among the thousands of residents in facilities that were vaccinated early, the incidence of new SARS-CoV-2 infections was significantly lower than would have been the case had the vaccinations occurred later. A similar pattern, although delayed by over a month, was observed for the composite

TABLE 2 Model-based estimates of differences in new SARS-CoV-2 infections per week and new hospitalizations or deaths per week, comparing residents in early versus late-vaccinated nursing homes^a

Incident SARS-CoV-2 infections per 100 at-risk residents per week	Hospital transfers and/or deaths per 100 residents with confirmed SARS-CoV-2 infection per day, averaged by week
Difference between early versus late vaccinating facilities (95% CI)	Difference between early versus late vaccinating facilities (95% CI)
Week before first vaccination dose	
Week 5 -0.2 (-0.7, 0.4)	-0.2 (-0.5, 0.1)
Week 4 0.2 (-0.6, 0.8)	0.0 (-0.4, 0.3)
Week 3 0.6 (-0.2, 1.3)	-0.1 (-0.4, 0.3)
Week 2 -0.7 (-1.5, 0.0)	-0.3 (-0.6, 0.0)
Week 1 0.5 (-0.3, 1.1)	0.0 (-0.4, 0.3)
Week after first vaccination dose	
Week 0 -1.6 (-3.2, -0.2)	0.1 (-0.3, 0.4)
Week 1 -2.5 (-4.0, -1.2)	0.4 (0.1, 0.8)
Week 2 -2.8 (-4.7, -1.0)	0.7 (0.3, 1.0)
Week 3 -4.0 (-5.7, -2.4)	0.5 (-0.1, 0.9)
Week 4 -3.8 (-5.4, -2.3)	0.4 (0.0, 0.7)
Week 5 -2.2 (-3.5, -1.0)	-3.8 (-4.2, -3.4)
Week 6 -1.3 (-2.6, -0.2)	-0.2 (-0.6, 0.1)
Week 7 -1.4 (-2.3, -0.8)	-1.1 (-1.4, -0.7)

^aWeek 0 is the week of a nursing home's first vaccine clinic. Early vaccinated nursing homes had their initial vaccine clinics between December 18, 2020, and January 2, 2021. Late vaccinated facilities had their initial clinics between January 3, 2021, and January 18, 2021. Deaths and hospitalizations within 30 days of a new positive SARS-CoV-2 test are included.

outcome of hospitalization or death among residents with confirmed infection. These reductions are clinically important and show the effectiveness of the vaccine in preventing new cases and reducing severe cases of COVID-19. The paragraphs below place these findings in the context of the broader experience of nursing home residents and the emerging literature on the effectiveness of these vaccines.

Recent data-based reports from the New York Times and Kaiser Family Foundation have documented the huge reduction in nursing home deaths that coincided with vaccination clinics.^{4,5} However, because publicly available national data on nursing home cases also reveal an 83% decline in new cases, these data are insufficient to determine whether these trends are due to the vaccination program. Using

detailed, longitudinal data from Genesis including resident-level testing and immunization data, we are able to link individuals' SARS-CoV-2 infection status, hospitalizations, and death data to a specific date on which they and/or others in their facility were vaccinated. Furthermore, because we are not merely comparing vaccinated and unvaccinated individuals, with all the associated potential bias, our comparison of residents in facilities vaccinated early with those who were awaiting vaccination removes individual-level confounding that complicates the interpretation of many observational vaccine studies.¹⁰

Whether an average 2.5 cases per 100 at-risk residents per week reduction is meaningful depends upon how one interprets the suggested cumulative reduction in both outcomes. Over the course of a 5- to 7-week period, we observed a clearly clinically meaningful reduction in new infections on the magnitude of 5.2 fewer cases per 100 at-risk residents. However, because the late vaccination facilities were already vaccinating their residents, this estimate of effect is very conservative. The same cumulative interpretation can be applied to the composite outcome of hospitalization or death because by weeks 5 to 7 the cumulative reduction in this outcome was on average 5 events per 100 infected residents per day. In addition to underestimating the true effect of vaccination of residents due to the short interval between early and late facilities, this morbidity and mortality outcome is more stringent and conservative because we predicate a COVID-19 death or hospital transfer only as someone with newly-confirmed SARS-CoV-2 infection in the prior 30 days. Events occurring more than 30 days after diagnosis are increasingly likely due to other causes because nursing home residents have high baseline hospitalization and mortality rates.^{11,12}

Our measure of SARS-CoV-2 incidence is based on both vaccinated and unvaccinated residents which have implications for our estimate of the impact of vaccination on reducing infections and deaths. Because SARS-CoV-2 testing happened systematically for the entire population, all asymptomatic, pre-symptomatic, and symptomatic cases were included in this outcome. The AstraZeneca¹³ vaccine study, an adenovirus vectored vaccine, also systematically tested all study volunteers weekly and found reductions, relative to controls, in both symptomatic and asymptomatic cases.¹³ Our study suggests a similar finding following only the first dose of the mRNA vaccines, but this interpretation requires additional data. These observations have added importance because nursing home residents typically represent a population that does not respond that well to vaccines due to underlying

disease and immunosuppression from medications, and immunosenescence.

Recent reports suggesting that the approved vaccines seem to be contributing to reductions in the rates of incident cases in the United States and elsewhere are of considerable interest because neither the Pfizer nor Moderna trials were designed to test for their impact on infection with the virus, only the occurrence of symptomatic illness. Nonetheless, our data clearly suggest that vaccination of nursing home residents protects against new cases of SARS-CoV-2. The fact that we are able to detect this even in the face of a substantial downward secular trend observed in both the nursing home and general population is all the more remarkable. Perhaps within the confines of a nursing home, which has limited traffic with the outside world, the protection offered by vaccination is more immediately apparent, even if the mechanism is not precisely understood.

This study has limitations, the most obvious of which is that we are attempting to detect an acceleration of reductions in SARS-CoV-2 incidence, morbidity, and mortality without the benefit of a randomized trial. Such a trial, however, would have meant introducing a “waiting list” control design into the Nursing Home Pharmacy Partnership for Long-Term Care Program, something that would have been extremely impractical and ethically questionable. Although resident vaccination rates across Genesis approached 85% as of the end of January,¹⁴ the new infections reported are based upon all cases and not just the vaccinated residents, making our estimate of effect more conservative. Genesis facilities are not necessarily representative of all other nursing homes in the country, so we cannot necessarily generalize our results to all U.S. nursing homes. Finally, residents transferred to hospitals may have died there which is why we created the potentially less sensitive composite measure of death or hospitalization.

In summary, our findings suggest that the vaccination of nursing home residents has reduced the morbidity and mortality of SARS-CoV-2 in the vulnerable nursing home population and contributed meaningfully to a substantial reduction in incident cases. Hopefully, this will make it possible for nursing homes to begin controlled efforts to open up to family visitation and alleviate other restrictions, thus reversing the social isolation which has become virtually universal during the pandemic.

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CONFLICTS OF INTEREST

Dr Mor reported grants from the National Institute on Aging and personal fees from naviHealth outside the submitted work. Dr. White reported personal fees from PACE Organization of Rhode Island outside the submitted work. Dr. Gravenstein reported grants from the National Institutes of Health during the conduct of the study. No other disclosures were reported.

AUTHOR CONTRIBUTIONS

Drs. White and Gutman and Ms. Yang had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Concept and design: Mor, Gutman, White, Feifer, Gravenstein. Acquisition, analysis, or interpretation of data: All authors. Drafting of the manuscript: Mor, Gutman, White, McGonaghy, Kosar, Gravenstein. Critical revision of the manuscript for important intellectual content: All authors. Statistical analysis: Gutman, Yang, McGonaghy, Bardenheier, Kosar. Obtained funding: Mor. Administrative, technical, or material support: White, Blackman Feifer, Gravenstein. Supervision: Feifer, Gravenstein, Mor.

SPONSOR'S ROLE

The National Institute on Aging had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

Supplementary Text S1. Detail of analytic methods

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