Title
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Journal
New England Journal of Medicine, 388(12)

ISSN
0028-4793

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Publication Date
2023-03-23

DOI
10.1056/nejmoa2210063

Peer reviewed

ORIGINAL ARTICLE

Covid-19 Surveillance Testing and Resident Outcomes in Nursing Homes

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ABSTRACT

BACKGROUND

Despite widespread adoption of surveillance testing for coronavirus disease 2019 (Covid-19) among staff members in skilled nursing facilities, evidence is limited regarding its relationship with outcomes among facility residents.

METHODS

Using data obtained from 2020 to 2022, we performed a retrospective cohort study of testing for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) among staff members in 13,424 skilled nursing facilities during three pandemic periods: before vaccine approval, before the B.1.1.529 (omicron) variant wave, and during the omicron wave. We assessed staff testing volumes during weeks without Covid-19 cases relative to other skilled nursing facilities in the same county, along with Covid-19 cases and deaths among residents during potential outbreaks (defined as the occurrence of a case after 2 weeks with no cases). We reported adjusted differences in outcomes between high-testing facilities (90th percentile of test volume) and low-testing facilities (10th percentile). The two primary outcomes were the weekly cumulative number of Covid-19 cases and related deaths among residents during potential outbreaks.

RESULTS

During the overall study period, 519.7 cases of Covid-19 per 100 potential outbreaks were reported among residents of high-testing facilities as compared with 591.2 cases among residents of low-testing facilities (adjusted difference, –71.5; 95% confidence interval [CI], –91.3 to –51.6). During the same period, 42.7 deaths per 100 potential outbreaks occurred in high-testing facilities as compared with 49.8 deaths in low-testing facilities (adjusted difference, –7.1; 95% CI, –11.0 to –3.2). Before vaccine availability, high- and low-testing facilities had 759.9 cases and 1060.2 cases, respectively, per 100 potential outbreaks (adjusted difference, –300.3; 95% CI, –377.1 to –223.5), along with 125.2 and 166.8 deaths (adjusted difference, –41.6; 95% CI, –57.8 to –25.5). Before the omicron wave, the numbers of cases and deaths were similar in high- and low-testing facilities; during the omicron wave, high-testing facilities had fewer cases among residents, but deaths were similar in the two groups.

CONCLUSIONS

Greater surveillance testing of staff members at skilled nursing facilities was associated with clinically meaningful reductions in Covid-19 cases and deaths among residents, particularly before vaccine availability.

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N Engl J Med 2023;388:1101-10.
DOI: 10.1056/NEJMoa2210063

Surveillance testing for coronavirus disease 2019 (Covid-19) is widely considered to be a critical tool in the control of pandemic outbreaks.[1,2] Because asymptomatic or presymptomatic persons are key vectors of disease spread,[3] regular surveillance testing for Covid-19 was mandated by many organizations with high-risk members and by closed communities, including health care facilities, prisons, and some workplaces. The utility and cost-effectiveness of surveillance testing is supported by several modeling studies,[4-10] but few studies with longitudinal, real-world data have examined outcomes of various testing strategies in a large population over time.[11,12]

An especially important setting for surveillance testing is skilled nursing facilities, whose residents and staff made up less than 2% of the U.S. population but more than 20% of Covid-19–related deaths by the end of 2021.[13] Presymptomatic staff members are probably the primary mechanism for the introduction of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) into skilled nursing facilities.[14-16] Federal authorities have suggested that routine Covid-19 screening of asymptomatic staff be performed up to twice weekly in skilled nursing facilities in areas of high SARS-CoV-2 transmission, although this practice was difficult to achieve at most facilities before 2021 because of testing and staffing shortages, supply-chain issues, and slow turnaround times for test results.[17,18]

The large size of the nursing home industry — 1.7 million staff and more than 4 million short- and long-stay residents[19] — and substantial variation in adoption of surveillance testing across more than 15,000 facilities provide a unique opportunity to evaluate the real-world effectiveness of surveillance testing approaches. We used comprehensive data on Covid-19 testing, staff and resident cases, and deaths in all federally accredited skilled nursing facilities to examine the relationship between testing strategies for staff — including frequency, test turnaround time, and test type (polymerase chain reaction [PCR] or antigen) — and risks of potential outbreaks of Covid-19 and associated deaths among residents.

Methods

Oversight and Data Sources

No outside agencies were involved in the design or conduct of this study. In accordance with policies regarding the use of publicly available data adopted by Harvard University (the institution of the third [senior] author), the study was exempt from review by an institutional review board. Harvard played no other role in the study.

The primary data source for this retrospective cohort study of U.S. skilled nursing facilities was the Covid-19 Nursing Home Database of the Centers for Medicare and Medicaid Services (CMS),[20] a mandatory repository that contains data (including Covid-19 cases and deaths) that are submitted on a weekly basis by skilled nursing facilities to the National Healthcare Safety Network (NHSN) of the Centers for Disease Control and Prevention. Data were obtained from November 22, 2020, to May 15, 2022, which corresponds to the period in which all relevant testing questions were included in the NHSN Covid-19 modules.

We obtained information about facility staffing from the CMS-mandated Payroll-Based Journal Employee Detail database. This database, which compiles individual-level staffing data from facility payroll records or other auditable sources, provides a record of daily individual staff shifts that can be used to determine staffing levels according to discipline (e.g., nursing and physical therapy), as well as the number of staff members who were working on a given day.[21] Additional data sources are detailed in the Supplementary Appendix, available with the full text of this article at NEJM.org.

Study Sample and Potential Outbreak Definition

To examine the relationship between surveillance testing and Covid-19 outcomes, we constructed a study sample consisting of facility-weeks during which skilled nursing facilities were having a potential outbreak of Covid-19. To allow for adequate follow-up time, we included data from potential outbreaks from November 22, 2020, to March 20, 2022. We defined the start of a potential outbreak within a facility as the first week during which any Covid-19 cases among staff or residents were reported after 2 consecutive weeks of no such reports within the facility. The week that the initial case had been identified was defined as the start of the potential outbreak (i.e., week 1), and we followed outcomes over subsequent weeks until there were two consecutive weeks with no new staff or resident cases or 7 follow-up weeks, whichever came first.

When a potential outbreak ended before 7 weeks of follow-up, we tracked Covid-19–related deaths among residents for an additional 2 weeks to account for the lag between the diagnosis of Covid-19 cases and deaths.

FREQUENCY OF SURVEILLANCE TESTING

First, we quantified the volume of surveillance (as opposed to diagnostic) testing as the total number of Covid-19 tests — including point-of-care (POC) and non-POC tests — that were administered to staff members during weeks in which facilities had no Covid-19 cases among either staff or residents. We normalized this measure to the size of the staff, defined as the weekly average number of persons with any reported hours in the payroll-based data during the first quarter of 2021. We performed winsorization (i.e., the limitation of extreme values to reduce the effect of possibly spurious outliers) on weekly data regarding the number of Covid-19 tests that had been administered per staff member at the 1st and 99th percentiles.

To address confounding between staff test volume and resident outcomes (Fig. S1 in the Supplementary Appendix), we used a regression framework to estimate the propensity of each facility for surveillance testing as compared with other skilled nursing facilities in the same county, a value that we defined as the relative testing rate (our primary exposure variable) over the entire study window. To determine the relative testing rate, we restricted the sample to all facility-weeks with no Covid-19 cases among staff or residents and used linear regression to calculate the number of weekly tests administered per staff member after adjustment for facility fixed effects, county-week fixed effects, and time-varying weekly measures of staff and resident vaccination rates (Section S1.4). We used the facility fixed effects from this model to define the relative testing rate (i.e., the latent, time-invariant propensity for surveillance testing relative to other facilities in the same county-week) after adjustment for vaccination rates among staff and residents. This value reflects the variation in surveillance testing that is not attributable to community-level risk, regional testing regulations, secular time trends, or degree of vaccine coverage.

STUDY OUTCOMES

Our two primary outcomes were the weekly cumulative number of Covid-19 cases and related deaths among residents, as reported by facilities in the NHSN database during a potential outbreak. Outcomes were reported as the number per 100 potential outbreaks. We focused on outcomes among residents because cases among staff members are, in part, a direct function of the key exposure — the number of tests that were performed among staff. In secondary analyses, we examined cumulative Covid-19 cases and related deaths among staff members.

ADDITIONAL STUDY VARIABLES

We captured testing type and test turnaround time as facility-level variables. For testing type, we determined the share of staff tests that were POC (i.e., antigen tests) as opposed to non-POC (typically, PCR tests) during the week before the start of a potential outbreak. This information was missing for 14% of potential outbreak pairs (Section S1.5). We classified potential outbreaks into two groups: those in which 50% or more of tests at baseline were POC and those that were not (<50% POC) (Fig. S2). We defined test turnaround time on the basis of survey responses during the week before a potential outbreak and during the first week of the outbreak as 2 days or less in both weeks or 3 days or more in either week. The test turnaround time was defined only for skilled nursing facilities that predominantly used non-POC testing (i.e., in ≥80% of staff tests) before the start of a potential outbreak, since POC tests have immediate turnaround by definition. Covariates included other facility characteristics and measures of Covid-19 risk (Section S1.6).

STATISTICAL ANALYSIS

We estimated the association between testing patterns and weekly resident Covid-19 outcomes within a potential outbreak using linear regression models. We estimated separate models for each outcome in which the key quantities of interest were interaction terms between relative testing rate (a continuous variable) and indicators for each potential outbreak week (i.e., weeks 1 to 8 during a potential outbreak). Models included facility- and county-level covariates, as well as county fixed effects and fixed effects for the calendar week in which the potential outbreak began. We performed multiple imputation for missing values in facility covariates and used the last nonmissing values to impute missing values in time-varying characteristics (i.e., the

availability of personal protective equipment) (Sections S1.6 and S1.7). Standard errors were clustered at the facility level. All 95% confidence intervals were not adjusted for multiplicity and should not be used in place of hypothesis testing. Because the key quantities of interest (relative testing rate according to potential outbreak week) were continuous variables, we report weekly estimates at two points in the relative testing rate distribution: the 90th percentile, representing high-testing facilities, and the 10th percentile, representing low-testing facilities.

To examine whether test volume had different effects during different phases of the pandemic, we stratified our analyses into three periods: before vaccine availability (November 22, 2020, to January 17, 2021), before the wave of the B.1.1.529 (omicron) variant (January 18 to October 31, 2021), and during the omicron wave (November 1, 2021, to March 20, 2022). We performed a series of sensitivity analyses to examine the robustness of our findings, including the use of alternate specifications of the covariates, indicators to account for missing covariate information, imputed data for missing information regarding the type of testing used, the estimation of Poisson rather than linear-regression models, the extension of follow-up time after the start of a potential outbreak, the restriction of analyses to actual outbreaks (i.e., two or more Covid-19 cases among residents), and the use of an alternate analytic framework that estimates the association between the surveillance test volume and resident outcomes according to variation over time within the same facility and estimation models that contain facility fixed effects (Section S1.7).

RESULTS

TESTING VOLUME

During the 77-week study window, we identified 13,424 study-eligible skilled nursing facilities and 66,900 potential outbreaks for an average of 5.0 potential outbreaks per facility. On average, sample facilities performed 1.1 surveillance tests per staff member per week (interquartile range, 0.4 to 1.5) (Fig. 1). Estimated relative rates of surveillance testing ranged from −0.8 to 1.6 tests per staff-week relative to the facility county-by-week average, such that high-testing facilities in the 90th percentile performed an additional 0.6 surveillance tests per staff-week relative to the county-week average, whereas low-testing facilities in the 10th percentile performed 0.5 fewer surveillance tests than the county-week average. Relative testing rates were predictive of actual test volumes (correlation coefficient, 0.51).

As compared with facilities in the bottom quartile of the relative testing rate, facilities in the top quartile were more likely to be nonprofit and to have a five-star quality score; in addition, top-quartile facilities had lower percentage of non-White residents, smaller staff sizes, older residents, and lower rates of reporting a shortage of personal protective equipment (Table 1). Facilities across all quartiles had a similar number of CMS-defined infection-control deficiencies during the most recent inspection. Missing data for facility characteristics ranged from 0.04 to 8.7% of sample observations (Table S1). The characteristics of the facilities in the top and bottom deciles of relative testing rates are shown in Table S3.

COVID-19 OUTCOMES

During a potential outbreak, high-testing facilities had fewer adjusted Covid-19 cases and deaths among residents than low-testing facilities (Fig. 2, Table 2, and Table S4). During the full study period, high-testing facilities had 519.7 cumulative resident Covid-19 cases per 100 potential outbreaks, as compared with 591.2 cases per 100 potential outbreaks in low-testing facilities, an adjusted difference of −71.5 cases (95% confidence interval [CI], −91.3 to −51.6). High-testing facilities had 42.7 cumulative resident Covid-19 deaths per 100 potential outbreaks, as compared with 49.8 deaths in low-testing facilities (adjusted difference, −7.1; 95% CI, −11.0 to −3.2). High-testing facilities had approximately 15% more Covid-19 cases among staff than low-testing facilities, with no appreciable differences in the number of deaths (Fig. S4).

The difference between high- and low-testing facilities was larger during the prevaccine period than after vaccines had become available. High-testing facilities had 759.9 cases as compared with 1060.2 cases per 100 potential outbreaks in low-testing facilities (adjusted difference, −300.3; 95% CI, −377.1 to −223.5). During this period, high-testing facilities had 125.2 deaths per 100

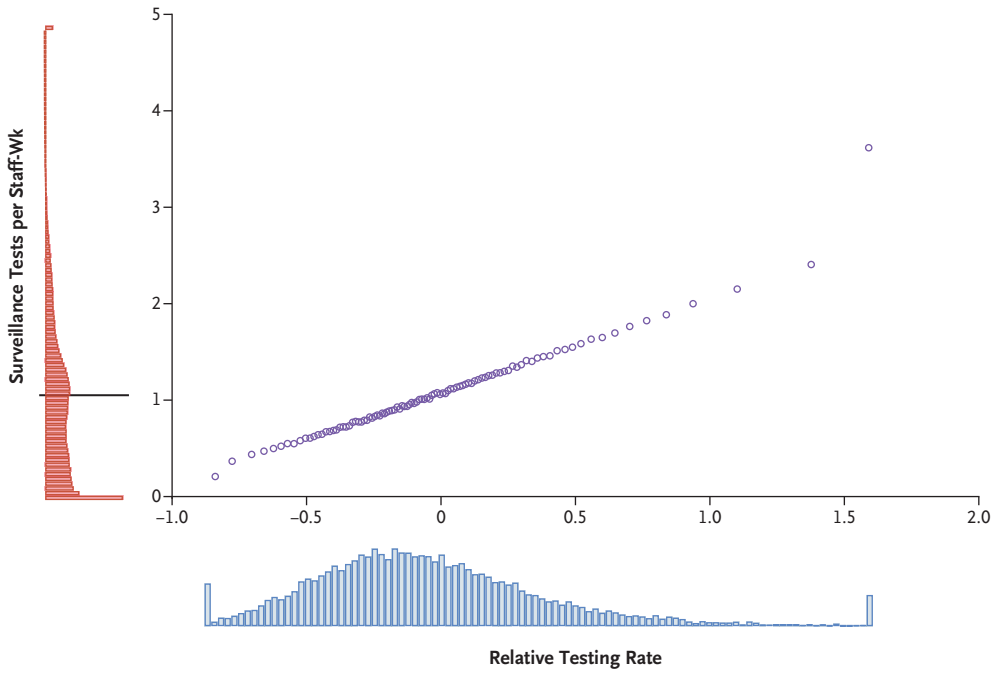

Figure 1. Correlation between Distribution of Observed Surveillance Test Volume and Estimated Relative Testing Rate.
Shown is the distribution of the surveillance test volume (y axis) and the estimated relative testing rate (x axis), as well as the association between the two measures (purple circles) on a binned scatter plot in which facility-week samples are divided into 100 equal-size categories according to their relative testing rate. The black horizontal line in the distribution of test volumes represents the mean test volume across all surveillance testing weeks. The clustering of observations at the extremes of the distributions reflect the winsorization of data to account for outliers.

potential outbreaks as compared with 166.8 deaths in low-testing facilities (adjusted difference, −41.6; 95% CI, −57.8 to −25.5). In an extrapolation of observed relative risks during the prevaccine period, the performance of 1 additional test per staff member per week across all facilities (i.e., approximately 1.1 million additional tests per week) was associated with 3079 fewer resident cases (30.5% reduction) and 427 fewer resident deaths (26.4% reduction) per week of heightened testing (Table S5).

After the availability of vaccines, the outcomes between high- and low-testing facilities were similar during the period before the omicron wave. During the omicron wave, high-testing facilities had 1038.2 resident cases per 100 potential outbreaks as compared with 1092.9 cases in low-testing facilities (adjusted difference, −54.7; 95% CI, −102.2 to −7.2). No appreciable between-group difference in Covid-19–related deaths among residents occurred during this period.

VARIATION ACCORDING TO TESTING CHARACTERISTICS

After adjustment for surveillance-testing volume, facilities that used POC tests had 537.6 resident Covid-19 cases per 100 potential outbreaks as compared with 509.4 residents in facilities using non-POC tests (adjusted difference, 28.2; 95% CI, 9.4 to 47.1) (Table 2, Table S6, and Fig. S5). The numbers of Covid-19–related deaths among residents were similar regardless of the type of testing that was performed during the full study window, as were the numbers of cases or deaths during the prevaccine phase (Fig. S6).

Among facilities that predominantly used non-POC tests before the start of a potential outbreak, faster test turnaround time was associated with fewer resident deaths. Facilities that had an average turnaround time of 2 days or less reported 41.6 resident deaths per 100 potential outbreaks, as compared with 59.1 resident deaths in facilities that received results in 3 days or more (adjusted difference, −17.5; 95% CI, −25.2

Table 1. Characteristics of Study Facilities, According to Relative Testing Rate.*

Characteristic	Quartile of Testing Rate†			
	1	2	3	4
No. of facilities	3516	3385	3278	3245
No. of certified beds	107.7±57.5	111.5±58.6	111.4±59.2	106.5±70.3
Profit status — no. (%)				
Nonprofit	660 (18.8)	745 (22.0)	800 (24.4)	965 (29.7)
Government owned	156 (4.4)	169 (5.0)	170 (5.2)	261 (8.0)
For profit	2700 (76.8)	2471 (73.0)	2308 (70.4)	2019 (62.2)
Percent of residents receiving Medicaid	60.0±23.5	60.8±21.5	59.8±22.0	57.4±24.1
Percent of residents with non-White race‡	22.6±22.7	20.9±22.3	18.7±21.2	16.3±20.2
Quality rating — no./total no. (%)§				
1	712/3474 (20.5)	567/3348 (16.9)	471/3245 (14.5)	475/3210 (14.8)
2	757/3474 (21.8)	685/3348 (20.5)	599/3245 (18.5)	574/3210 (17.9)
3	609/3474 (17.5)	597/3348 (17.8)	598/3245 (18.4)	563/3210 (17.5)
4	677/3474 (19.5)	727/3348 (21.7)	750/3245 (23.1)	683/3210 (21.3)
5	719/3474 (20.7)	772/3348 (23.1)	827/3245 (25.5)	915/3210 (28.5)
Hours of registered-nurse care per resident-day — no.	0.74±0.62	0.69±0.45	0.72±0.48	0.79±0.57
Hours of direct care per resident-day — no.	3.9±1.1	3.8±0.9	3.9±1.0	4.0±1.2
No. of staff members per day	152.3±83.6	146.7±78.9	143.1±81.1	135.6±80.9
Resident age — yr	78.6±7.1	79.2±6.6	79.5±7.3	80.3±7.3
Resident Acuity Index¶	12.2±1.4	12.2±1.4	12.2±1.4	12.2±1.5
No. of infection-control deficiencies‖	0.55±0.74	0.52±0.72	0.51±0.71	0.51±0.71
No. of potential outbreaks	17,136	17,435	17,494	17,835
No. of Covid-19 cases				
Residents	43.1±29.0	42.3±27.7	40.0±27.3	37.0±29.4
Staff	39.3±27.6	40.1±24.1	40.0±24.3	42.9±38.2
Percent of vaccination coverage				
Residents	69.5±33.4	72.2±32.8	73.4±32.8	74.8±33.0
Staff	58.2±32.4	60.1±31.7	60.5±31.6	61.4±31.6
County Covid-19 new case rate — no./ 100,000 population	51.5±58.2	48.7±53.4	46.4±50.3	44.6±47.5
<1-Wk supply of personal protective equipment — no./total no. (%)				
N95 masks	373/17,136 (2.2)	416/17,435 (2.4)	392/17,494 (2.2)	341/17,835 (1.9)
Surgical masks	288/17,136 (1.7)	298/17,435 (1.7)	258/17,494 (1.5)	214/17,835 (1.2)
Eye protection	263/17,136 (1.5)	299/17,435 (1.7)	243/17,494 (1.4)	211/17,835 (1.2)
Gowns	266/17,136 (1.6)	252/17,435 (1.4)	246/17,494 (1.4)	212/17,835 (1.2)
Gloves	232/17,136 (1.4)	235/17,435 (1.3)	228/17,494 (1.3)	187/17,835 (1.0)

* Plus–minus values are means ±SD. Listed are data for the entire 77-week study window.
† Quartiles of testing rate range from the lowest (quartile 1) to the highest (quartile 4). The mean relative testing rate within the quartile was –0.50 in quartile 1, –0.19 in quartile 2, 0.06 in quartile 3, and 0.59 in quartile 4.
‡ Race was determined according to patients' records at each facility. Small sample sizes preclude estimation of specific minority race proportions in many nursing homes owing to data-suppression rules.
§ Quality ratings ranging from 1 (lowest) to 5 (highest) were determined by the Centers for Medicare and Medicaid Services (CMS).
¶ The Acuity Index indicates the level of care (e.g., in activities of daily living and in specialized medical treatments) that is needed by residents of the facility. The index ranges from 0 to 24, with higher values indicating a greater need for care.
‖ This value indicates the number of infection-control deficiencies that were identified during the most recent CMS health and safety inspection as of July 2022.

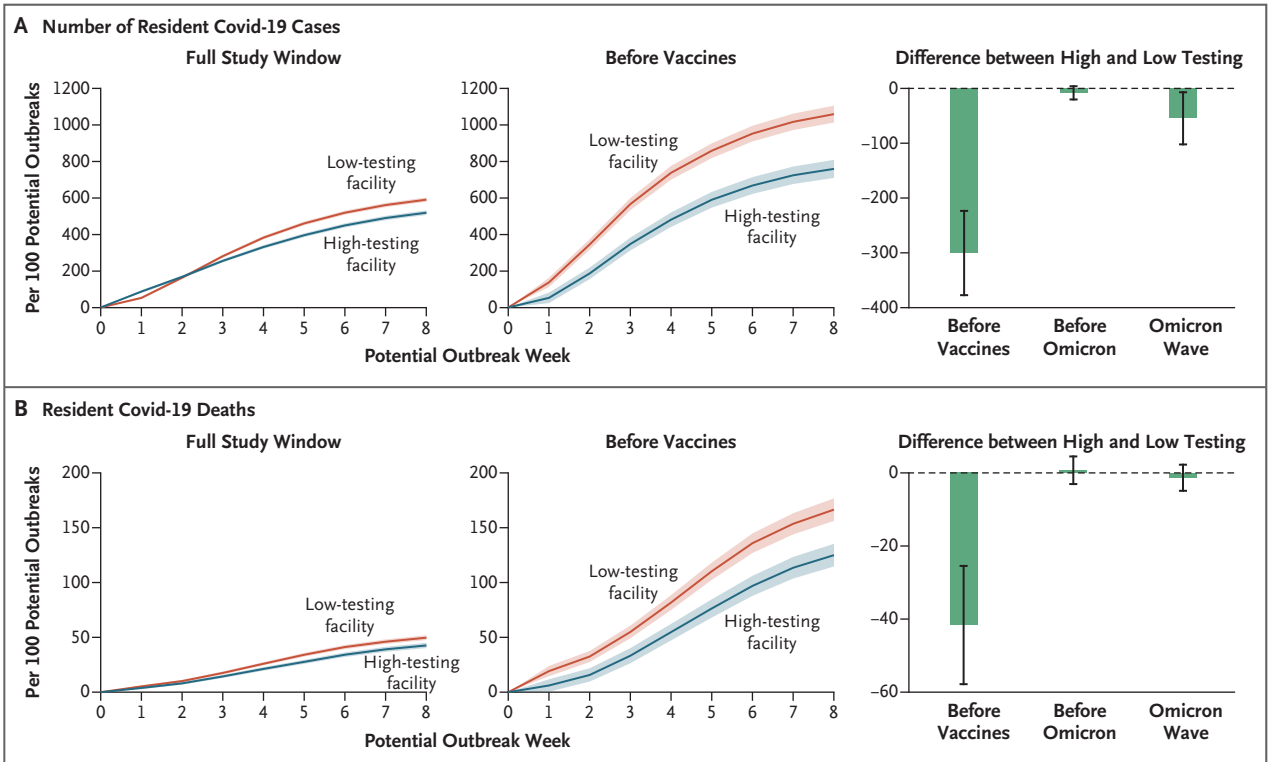

Figure 2. Association of Surveillance Testing Volume among Staff and Covid-19 Outcomes among Residents.

Shown are the results of regression analysis of coronavirus disease 2019 (Covid-19) cases (Panel A) and deaths (Panel B) among residents of skilled nursing facilities (measured as the number of resident cases or deaths per 100 potential outbreaks), according to the level of surveillance testing of staff members. In the graph at left in each panel, data are shown for the full study window (potential outbreaks from November 22, 2020, to March 20, 2022); in the middle graph, for the period before vaccines were available (November 22, 2020, to January 17, 2021); and in the graph at right, for the differences between high-testing facilities and low-testing facilities during the period before vaccines were available, before the wave of the B.1.1.529 (omicron) variant (January 18 to October 31, 2021), and during the omicron wave (November 1, 2021, to March 20, 2022). Shading and I bars indicate 95% confidence intervals. Confidence intervals were not adjusted for multiplicity and may not be used in place of hypothesis testing. Details regarding the regression analyses are provided in Section S1.6.

to −9.8) (Fig. 3 and Table S7). During the prevaccine phase, these differences were more marked; facilities with turnaround times of 2 days or less had 112.0 fewer cases (95% CI, −221.0 to −3.0) and 44.1 fewer deaths (95% CI, −68.6 to −19.7) than facilities with turnaround times of 3 days or more (Fig. S7).

We performed multiple sensitivity analyses to confirm the main study findings. The results of these analyses were similar to the main results (Fig. S8 and Tables S8 through S11).

DISCUSSION

We found that greater surveillance testing of staff members in skilled nursing facilities was associated with clinically meaningful reductions in Covid-19 cases and deaths among residents, particularly before the availability of highly effective vaccines. Greater surveillance testing was also associated with more Covid-19 cases among staff during potential outbreaks, findings that were consistent with the protection of residents through the increased detection of Covid-19 among staff members. In addition, such detection may have occurred earlier in the disease course, thereby disrupting potential viral transmission chains. Little difference was detected between facilities that predominantly used POC testing and those that used non-POC testing, but faster turnaround times for testing results were associated with reductions in resident deaths

Table 2. Estimated Differences in Resident Covid-19 Cases and Deaths, According to Testing Characteristics.*

Variable	Covid-19 Cases (95% CI)				Covid-19 Deaths (95% CI)			
	Overall	Before Vaccines†	Before Omicron Wave‡	During Omicron Wave§	Overall	Before Vaccines†	Before Omicron Wave‡	During Omicron Wave§
	number of residents per 100 potential outbreaks							
Test volume¶								
High-testing facility	519.7 (507.1 to 532.2)	759.9 (710.3 to 809.6)	192.9 (185.4 to 200.5)	1038.2 (1007.2 to 1069.3)	42.7 (40.3 to 45.1)	125.2 (114.8 to 135.6)	25.2 (22.8 to 27.5)	38.9 (36.6 to 41.2)
Low-testing facility	591.2 (579.0 to 603.3)	1060.2 (1013.8 to 1106.6)	201.2 (193.5 to 209.0)	1092.9 (1065.1 to 1120.8)	49.8 (47.6 to 52.0)	166.8 (156.5 to 177.1)	24.4 (22.5 to 26.4)	40.2 (38.0 to 42.4)
Difference	−71.5 (−91.3 to −51.6)	−300.3 (−377.1 to −223.5)	−8.3 (−20.4 to 3.7)	−54.7 (−102.2 to −7.2)	−7.1 (−11.0 to −3.2)	−41.6 (−57.8 to −25.5)	0.7 (−3.1 to 4.5)	−1.4 (−4.9 to 2.2)
Test type‖								
POC	537.6 (527.7 to 547.5)	841.0 (792.9 to 889.1)	201.5 (194.7 to 208.2)	1030.0 (1008.5 to 1051.4)	43.9 (42.1 to 45.6)	139.6 (127.8 to 151.4)	26.5 (24.8 to 28.1)	40.5 (38.8 to 42.3)
Non-POC	509.4 (494.9 to 523.8)	784.5 (739.2 to 829.8)	184.0 (175.1 to 192.9)	1096.7 (1052.4 to 1140.9)	40.7 (38.2 to 43.2)	124.4 (113.1 to 135.6)	22.1 (20.2 to 24.0)	38.7 (35.5 to 41.8)
Difference	28.2 (9.4 to 47.1)	56.5 (-15.8 to 128.9)	17.5 (5.5 to 29.4)	−66.7 (−118.5 to −14.9)	3.2 (−0.1 to 6.4)	15.2 (-3.4 to 33.8)	4.3 (1.5 to 7.1)	1.9 (−1.9 to 5.6)
Turnaround time**								
0–2 Days	483.6 (466.7 to 500.4)	776.8 (717.4 to 836.2)	162.1 (153.1 to 171.1)	1105.9 (1055.7 to 1156.0)	41.6 (39.1 to 44.1)	115.6 (104.1 to 127.1)	20.1 (18.2 to 22.0)	36.4 (33.0 to 39.8)
≥3 Days	510.1 (476.9 to 543.3)	888.8 (809.2 to 968.4)	169.1 (150.3 to 187.9)	1168.8 (1039.3 to 1298.3)	59.1 (52.1 to 66.1)	159.7 (139.7 to 179.8)	22.9 (18.8 to 27.0)	34.6 (26.8 to 42.3)
Difference	−26.5 (−65.8 to 12.8)	−112.0 (−221.0 to −3.0)	−7.0 (−29.3 to 15.3)	−62.9 (−211.0 to 85.1)	−17.5 (−25.2 to −9.8)	−44.1 (−68.6 to −19.7)	−2.8 (−7.5 to 2.0)	1.8 (−7.3 to 10.9)

* The number of Covid-19 cases and deaths among residents of skilled nursing facilities was measured at the end of a potential outbreak per 100 potential outbreaks. Marginal estimates and 95% confidence intervals were calculated from regression analyses estimating differences in resident Covid-19 cases and deaths between facilities on three dimensions: relative testing rate, point-of-care (POC) testing versus non-POC testing, and mean turnaround times of non-POC testing in 2 days or less versus 3 days or more. Details regarding the regression analyses are provided in Section S1.6.

† The period before vaccine availability was defined as November 22, 2020, to January 17, 2021.

‡ The period before the first wave of the SARS-CoV-2 B.1.1.529 (omicron) variant was defined as January 18 to October 31, 2021.

§ The period during the first omicron wave was defined as November 1, 2021, to March 20, 2022.

¶ In the test-volume category, 69,900 potential outbreaks occurred in all the facilities during the overall study window.

‖ In the test-type category, 59,930 potential outbreaks occurred during the overall study window because test-type information was missing for 9970 potential outbreak pairs. Results after the imputation of missing values are provided in Table S11.

** Analyses regarding turnaround times were restricted to 19,528 potential outbreaks in which a facility predominantly reported the results of non-POC tests (i.e., ≥80% of staff tests) before the start of the potential outbreak.

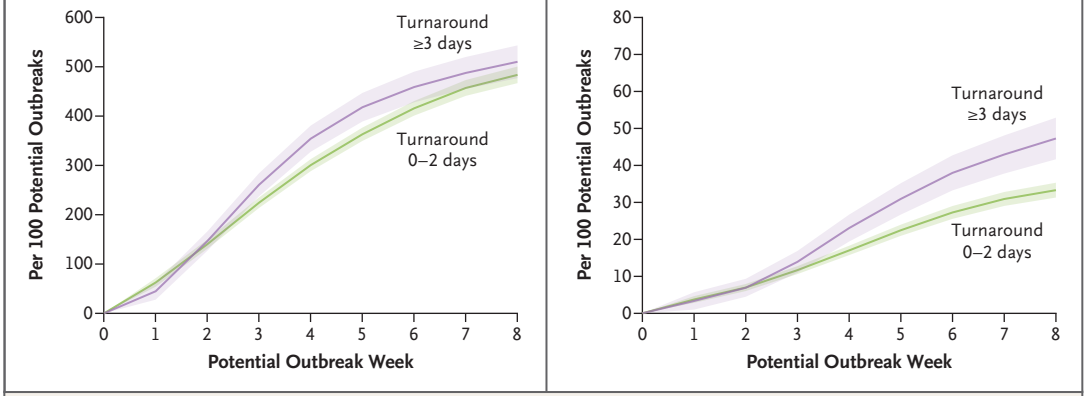

Figure 3. Association of Turnaround Time for Test Results and Covid-19 Outcomes among Residents.

Shown are the results of regression analysis of Covid-19 cases (Panel A) and deaths (Panel B) among residents of skilled nursing facilities (measured as the number of resident cases or deaths per 100 potential outbreaks) during the full study window according to the average length of turnaround time for testing results (≥3 days or 0 to 2 days), as measured at the start of a potential outbreak. The analyses were restricted to potential outbreaks in which a facility reported that the predominant testing method was not point-of-care (typically, polymerase-chain-reaction assay) before the start of the potential outbreak. Confidence intervals (shaded areas) were not adjusted for multiplicity and may not be used in place of hypothesis testing.

among facilities that were highly reliant on non-POC tests that required laboratory processing.

Previous simulation-based studies have suggested important features of an effective surveillance testing system, including testing at least twice weekly in high-risk settings[3,4,7] and immediately providing test results.[3,7] Such studies have also suggested limited benefit from using tests with greater sensitivity for detecting SARS-CoV-2.[7,10] The findings of our current real-world study largely support the conclusions of the modeling studies.

During the prevaccine phase of the pandemic, we found that the performance of one additional test per staff member per week was associated with a 30% reduction in resident Covid-19 cases and a 26% reduction in related resident deaths. In addition, a shorter test turnaround time (≤2 days as compared with ≥3 days) was associated with fewer cases and deaths in facilities that predominantly performed non-POC tests. During the full study period, the use of non-POC tests was associated with only modest reductions in the number of cases and no reduction in deaths. Because POC tests are less expensive than non-POC tests ($5 vs. $100 per test),[22,23] frequent testing may be more financially feasible with POC testing. In addition, the use of POC tests avoids delays in laboratory turnaround time.

Surveillance testing was not strongly associated with differences in the numbers of cases or deaths during the preomicron phase, findings that are consistent with data showing that the available Covid-19 vaccines were highly effective at preventing both SARS-CoV-2 infections and severe disease.[24-26] Similarly, the finding that more frequent surveillance testing was associated with fewer resident cases but no difference in resident Covid-19 deaths during the omicron wave is consistent with documented reductions in vaccine efficacy for preventing Covid-19 infections but maintenance in efficacy for preventing hospitalizations and deaths.[27,28]

Our study has several limitations. Our observational study design precludes a conclusion of causality. Although our analyses were adjusted for several facility- and county-level covariates, we cannot rule out the possibility of unmeasured confounding as a driver of differences among facilities with higher as compared with lower relative testing rates. However, the finding that greater testing volume was associated with fewer resident cases but more staff cases suggests that our measure of testing rate is not simply a proxy for facility quality or underlying risk of Covid-19 outbreaks, both of which should have affected staff and resident cases in the same direction. We could not account for the potential contribu-

tion of outside visitors to infection rates. However, during the pandemic, visitors were largely banned from skilled nursing facilities before 2021 for infection control, so this factor would be unlikely to bias our prevaccine estimates. In addition, we lack data on resident and staff vaccination rates before June 2021, when these data were first reported in the NHSN system, as well as data regarding booster vaccinations.

We found that higher rates of surveillance testing of staff in U.S. skilled nursing facilities were associated with fewer resident Covid-19 cases and deaths regardless of testing method (POC or non-POC). These effects were most pronounced during the prevaccine time period and among facilities with faster turnaround times for non-POC testing.

Dr. Barnett was supported by a grant (K23 AG058806) from the National Institute on Aging.

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

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