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Original Study

Variation in Excess Mortality Across Nursing Homes in the Netherlands During the COVID-19 Pandemic



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ABSTRACT

Keywords:

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Objectives: Nursing home residents constituted a vulnerable population during the COVID-19 pandemic, and half of all cause-attributed COVID-19 deaths occurred within nursing homes. Yet, given the low life expectancy of nursing home residents, it is unclear to what extent COVID-19 mortality increased overall mortality within this population. Moreover, there might have been differences between nursing homes in their ability to protect residents against excess mortality. This article estimates the number of excess deaths among Dutch nursing home residents during the pandemic, the variation in excess deaths across nursing homes, and its relationship with nursing home characteristics.

Design: Retrospective, use of administrative register data.

Setting and Participants: All residents (N = 194,432) of Dutch nursing homes (n = 1463) in 2016–2021.

Methods: We estimated the difference between actual and predicted mortality, pooled at the nursing home level, which provided an estimate of nursing home-specific excess mortality corrected for resident case-mix differences. We show the variation in excess mortality across nursing homes and relate this to nursing home characteristics.

Results: In 2020 and 2021, the mortality probability among nursing home residents was 4.0 and 1.6 per 100 residents higher than expected. There was considerable variation in excess deaths across nursing homes, even after correcting for differences in resident case mix and regional factors. This variation was substantially larger than pre-pandemic mortality and was in 2020 related to pre-pandemic spending on external personnel and satisfaction with the building, and in 2021 to pre-pandemic staff absenteeism.

Conclusions and Implications: The variation in excess mortality across nursing homes was considerable during the COVID-19 pandemic, and larger compared with pre-pandemic years. The association of excess mortality with the quality of the building and spending on external personnel indicates the importance of considering differences across nursing home providers when designing policies and guidelines related to pandemic preparedness.

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Nursing home residents constituted a very vulnerable population during the COVID-19 pandemic. Their frail health increased their risk of dying from the virus when infected, whereas their shared residence,

need for personal care, and limited ability to communicate symptoms left them more exposed to infection.^{1–4} As a result, during the first waves of the pandemic, the COVID-19 mortality risk was much higher among nursing home residents than non-nursing home residents.^{5–7} In the Netherlands, 21 thousand nursing home residents died of COVID-19 in 2020 and 2021, which is more than half of the total number of COVID-19 deaths.

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To improve policy, it is crucial to understand the potential for nursing homes to manage and prevent the consequences of infectious outbreaks, including mortality during the COVID-19 pandemic. Two literature reviews highlight an increasing number of studies

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documenting wide variation in COVID-19 deaths across nursing homes, which show that this variation relates to nursing home characteristics, such as nursing home's size, number of staff members, and other quality measures.^{3,8} However, these studies generally have 2 important limitations. First, most studies have focused on cause-identified COVID-19 mortality or deaths as an outcome when analyzing the role of nursing home quality and staffing levels.⁹⁻¹³ This can be problematic because COVID-19 as a cause of death may be misclassified because of inadequate access to tests,¹⁴ because not all COVID-19 deaths are excess deaths as COVID-19 may displace other causes of deaths,¹⁵ and because it neglects the indirect consequences of the pandemic, such as less access to medical care services. Second, not all studies fully controlled for regional differences or resident risk factors across nursing homes.³ These studies may be biased because resident characteristics and COVID-19 prevalence in the community explain a large part of the variation across nursing homes.^{8,10,16-20}

This article contributes to this evidence by using a novel measure of excess mortality as an outcome, while examining both the variation in excess mortality across nursing homes during the COVID-19 pandemic, and its associations with certain nursing home characteristics. More specifically, we focused on all-cause mortality instead of COVID-19 mortality alone and followed a recent study by Tenso et al. by predicting expected mortality based on resident characteristics and then calculate the mortality in excess of this prediction during the COVID-19 pandemic for each nursing home.²¹ For this, we combined publicly reported information on characteristics of all nursing homes and detailed administrative registers for all nursing home residents in the Netherlands over 2016-2021. This allowed us to control for (observable) differences in resident case mix across nursing homes and to observe cause-identified COVID-19 deaths to analyze the extent to which studies based on COVID-19 deaths over- or underestimate the pandemic's impact on mortality in nursing homes. The latter complements the work by Tenso et al.,²¹ who could not observe cause-identified COVID-19 deaths. Finally, we included nursing home characteristics in our model to evaluate their relationship with excess mortality.

Methods

Data Sources and Sample Selection

We used administrative data at the individual level from 2016 to 2021 provided by Statistics Netherlands, covering the entire Dutch population (see [Supplementary Material 1](#) for more information). These data were linked to data at the nursing home level from annual reports published by the Ministry of Health, quality reports published by the Dutch Healthcare Institute, and online user ratings from the website Zorgkaart Nederland. All nonprofit nursing home providers are obliged to provide this information on a yearly basis.

The study population included all individuals who lived in a nursing home in the Netherlands on January 1 in 2020 or 2021, were at least 65 years old and had no missing information on individual-level characteristics ($n = 68,328$ in 2020; $n = 70,118$ in 2021) (a flowchart of sample construction can be found in [Supplementary Figure 1](#)). We focus on individuals with a permanent nursing home stay, which excludes residents receiving post-acute rehabilitation care and short-term (medical) stays. We constructed a second sample to predict the individual-level probability of dying had there not been the COVID-19 pandemic, consisting of nursing home residents on January 1 in 2016-2019 ($N = 161,174$).

Excess Mortality and Case-Mix Variables

The main dependent variable is excess mortality, which is defined as the difference between the actual and predicted probability of

death in the absence of COVID-19. The approach to predict the latter is detailed in the Analytic Approach section.

Independent Variables: Nursing Home Characteristics

The nursing home characteristics covered 3 aspects of quality: structure, processes, and outcomes.²² Structure indicators covered location size (measured by the number of residents), organization's chain size (number of locations), staff quantity (full-time equivalent personnel per resident), staff absenteeism, expenditures on external personnel, and financial performance (defined by a self-constructed proxy, as defined in [Supplementary Table 2](#)). Process indicators included the share of all nursing home residents in a given month taking psychotropic medication and the share of residents for which staff use physical restraint measures in a given month. Finally, outcome indicators included prepandemic online ratings, reflecting user-reported satisfaction with several indicators of the nursing home provider. To limit bias from reverse causality, we used data from the year 2018, which was the last year for which data were reported by nursing homes before the pandemic.

To control for the variation in COVID-19 cases and other differences related to mortality during the pandemic across regions, we used indicators for the 32 regions in which long-term care is purchased and organized (in Dutch: zorgkantoorregio's).

Analytic Approach

The empirical analysis consisted of 3 steps. First, we estimated the probability of dying in 2020 and 2021 for each nursing home resident given their own observed characteristics in case the COVID-19 pandemic would not have happened. For this, we estimated a pooled logistic regression model using data from years prior to the pandemic to predict annual mortality for the years 2016-2019 using a broad set of background characteristics. The set of background characteristics included age, sex, number of days since nursing home admission, care profile (Dutch: Zorgzwaarte pakket), the reason for eligibility for long-term care (eg, predominantly driven by cognitive or physical issues), hospital visits (yes/no and number of days), health care expenditures, medication use, being diagnosed with heart failure or stroke, Charlson Comorbidity Index,²³ income and wealth, and region of residence. All these variables were measured on January 1 each given year, the calendar year prior to each given year, or the calendar year prior to the individual's nursing home admission. [Supplementary Table 1](#) provides a detailed overview of these variables. The estimated coefficients reflect the relationship between the characteristics and the annual probability to die in absence of the pandemic, which were used to predict the probability to die in 2020 or 2021 for individuals living in a nursing home on January 1 in 2020 and 2021, based on their characteristics.

Second, we obtained nursing home-specific estimates for excess mortality for 2020 and 2021 separately. We regressed excess mortality, which is the difference between actual and predicted mortality from step 1, on region and nursing home random effects in a multi-level model. Then, we retrieved the best linear unbiased predictions (BLUPs) of excess mortality for each nursing home. For this, we used the empirical Bayes mean predictions of the random effects provided by the *predict reffects* after the *xtmixed* command in Stata. The advantage of this estimator is that for (small) nursing homes for which we have relatively little information on the outcomes, the predicted score is more strongly shrunk toward the mean.

Third, we assessed the relationship between nursing home characteristics and excess mortality. We did this for 2020 and 2021 separately to account for differences between these years in, for example, the availability of vaccines, protective equipment, and learning effects. For each year, we ran 3 separate mixed effects regressions where we regressed the difference between actual and predicted mortality

including region and nursing home random effects and the 3 different types of nursing home characteristics, which were loaded on the level of the nursing home level random effects. To compare the magnitude of the relationship across the different characteristics, we divided them to the characteristic's SD. More detail regarding the analytical approach can be found in [Supplementary Material 1](#).

Results

Study Cohort

In all samples, the nursing home residents were on average aged 85-86 years and had high health care expenditures, hospital care utilization, and medication consumption. About half of the residents were in a

nursing home to receive dementia care, indicated by their care profile (see [Supplementary Table 1](#) for explanation) ([Table 1](#)). The main differences between the 3 samples were driven by sample construction: individuals admitted to a nursing home before the year 2015 were excluded (a sensitivity analysis is included in [Supplementary Material 1](#)).

[Supplementary Table 3](#) shows the characteristics for all 1463 nursing home locations and the 244 corresponding organizations that had complete information on the structure characteristics and could be linked to at least 1 nursing home resident in 2020 or 2021.

Predicted and Excess Mortality

The predicted probability to die varied between 4% and 94% at the individual level and was higher among people who died within

Table 1
Characteristics of Nursing Home Residents

	Study Sample (by Observation Year)		
	2016-2019	2020	2021
Outcomes			
Death in observation year, %	29.4	34.4	32.1
COVID death in observation year, %	0.0	7.0	5.1
Characteristics at January 1 in observation year			
Age, y, mean \pm SD	85.3 \pm 7.2	85.7 \pm 7.3	85.7 \pm 7.4
Women, %	68.4	69.3	70.1
Number of days since admission, mean \pm SD	419.6 \pm 329.7	643.3 \pm 469.5	704.7 \pm 545.7
Care profile, %			
4 (least severe)	20.7	18.7	16.2
5	52.7	52.4	52.5
6	21.0	21.3	22.7
7	4.7	6.6	7.4
8 (most severe)	0.8	1.0	1.1
Eligibility grounds, %			
Physical	32.1	30.4	30.3
Cognitive	62.2	61.8	61.6
Other	5.7	7.8	8.1
Characteristics in calendar year before observation year			
Hospital care expenditures (1000€), mean \pm SD	4175.3 \pm 9550.4	3257.6 \pm 8414.2	3653.6 \pm 9256.0
Had at least one hospital admission*, %	31.8	23.4	20.1
Number of hospital days, mean \pm SD	5.0 \pm 11.2	3.6 \pm 9.7	2.7 \pm 7.9
Hospitalized with heart failures [†] , %	1.8	1.4	1.1
Hospitalized with stroke [†] , %	3.8	2.7	2.3
Charlson Comorbidity Index [‡] , mean \pm SD	0.1 \pm 0.4	0.1 \pm 0.3	0.1 \pm 0.3
Household wealth from assets and savings (1000€), mean \pm SD	7.5 \pm 30.4	7.6 \pm 30.3	7.8 \pm 30.6
Disposable household income [§] (1000€), mean \pm SD	2.1 \pm 1.1	2.2 \pm 1.7	2.2 \pm 1.0
Characteristics in calendar year before nursing home admission			
Other care expenditures (1000€), mean \pm SD	5.6 \pm 12.2	5.7 \pm 12.4	5.7 \pm 12.7
Number of medication types ^{**} , mean \pm SD	8.2 \pm 4.8	8.3 \pm 4.8	8.2 \pm 4.7
Medication for, %^{**}			
Acid-related disorders	51.3	52.4	52.6
Bone diseases (osteoporosis)	9.9	9.2	8.9
Cardiovascular diseases (incl. hypertension)	75.4	75.2	75.0
Dementia	9.9	8.3	7.5
Diabetes	19.9	19.5	18.9
Epilepsy	6.7	7.1	7.4
Glaucoma	7.5	7.4	7.2
Hyperlipidemia	39.1	40.7	40.9
Iron deficiency anemia	6.3	6.1	6.0
Pain	22.7	24.3	22.0
Parkinson	5.8	5.9	5.9
Psychological disorders	24.6	25.2	25.3
Psychoses	12.5	12.0	11.6
Respiratory illness	15.6	15.2	15.1
Rheumatologic conditions	14.0	13.8	14.0
Thyroid	8.4	8.8	9.0
Observations	167,174	68,328	70,118

*Hospital admissions cover inpatient visits, 1-day visits, long-term observations, and ambulatory care visits.

[†]International Classification of Diseases, Tenth Revision, codes used for definition reported in [Supplementary Table 1](#).

[‡]Charlson Comorbidity Index using the definition by Sundararajan et al²³; see also [Supplementary Table 1](#).

[§]Household income is the household's gross income minus contributions to social premiums, standardized for household size.

^{||}We use data from the year prior to the nursing home admission for other care expenditures (including GP care) and prescribed medication as these are facilitated by the nursing homes and hence not individually recorded after admission.

^{**}Medication measured according to the Anatomical Therapeutic Chemical (ATC) classification system at level 3, definitions reported in [Supplementary Table 1](#).

that year, confirming that the probabilities are to some extent predictive both in- and out-of-sample (Supplementary Figure 2). We validated the performance of our prediction model for the 2016-2019 sample by estimating the area under the receiver operating characteristic curve using cross-validation to generate test and training samples.²⁴ The mean area under the curve is equal to 0.646 (with 95% CIs 0.642 to 0.648), which is considered low, but not exceptional when predicting deaths in a sample with a high death rate.²⁵ Predicted mortality, based on the individuals' observable characteristics, slightly increased over time: from 29% in 2016-2017 to 30% in 2020-2021 (Table 2), likely because of the study population construction.

Excess mortality was close to zero in all years from 2016 up to 2019, meaning there was no clear trend in excess mortality before the pandemic, except for the year 2018 characterized by an intense influenza wave. In 2020 and 2021, we observed excess mortality of 0.040 and 0.016, which equaled 4.0 and 1.6 excess deaths per 100 residents. Cause-specific COVID-19 mortality was higher than excess mortality: in 2020, 7.0 per 100 nursing home residents died from COVID-19. In contrast, mortality from other causes among nursing home residents was lower than expected in 2020—per 100 residents, 3.0 fewer individuals died from other causes.

Variation in Excess Mortality Across Nursing Homes

Nursing home-level excess mortality varied; nursing homes at the end of the left tail of the distribution had 10 fewer excess deaths per 100 residents compared with those at the far-right tail (Figure 1). Specifically, in 2020 there were no additional deaths compared to predicted in the 5% nursing homes with lowest excess mortality up to 9.8 more deaths than predicted per 100 residents in the 5% with highest excess mortality in 2020. In 2021, this ranged from 3.0 fewer up to 7.1 more deaths per 100 residents. The full distribution was wider for the year 2020 than in 2021; Supplementary Figure 3 shows that this was mainly driven by the larger variation in mortality during the first wave of the pandemic.

The nursing home excess mortality estimates in Figure 1 take differences in resident characteristics across nursing homes into account via the predicted probabilities (see also equation (1) in Supplementary Material 1). Supplementary Figure 4 shows that the variation across nursing homes would be overestimated if these observed differences are not controlled for.

The variation in excess mortality across nursing homes during the pandemic was considerably larger than during prepandemic years. Supplementary Figure 5 shows a wider distribution for excess mortality in 2020 and in 2021 as compared to previous years. The variances of the nursing home-specific random effects in 2020 and 2021 were 4 to 10 times as large as those in 2016-2019.

Table 2
Average Predicted, Actual All-Cause, Excess, and Actual COVID-19 Mortality by Year

	Year					
	2016	2017	2018	2019	2020	2021
Predicted mortality	0.291	0.290	0.293	0.298	0.304	0.305
Actual mortality	0.287	0.290	0.297	0.296	0.344	0.321
Excess mortality (= actual – predicted)	–0.004	0.000	0.004	–0.002	0.040	0.016
COVID-19 mortality	—	—	—	—	0.070	0.051
Observations	20538	37052	50837	58747	68328	70118

Table reports average predicted mortality, actual mortality, excess mortality, and COVID-19 mortality for individuals living in a nursing home at the beginning of each year (in columns). Predicted mortality is calculated based on resident characteristics and the estimated relationship between these characteristics and mortality in 2016-2019 (see also detailed methods section in Supplementary Material 1). Actual mortality is the average probability of dying within the calendar year. Excess mortality equals actual minus predicted mortality. COVID-19 mortality is the average probability of dying from COVID-19, based on data from death registries.

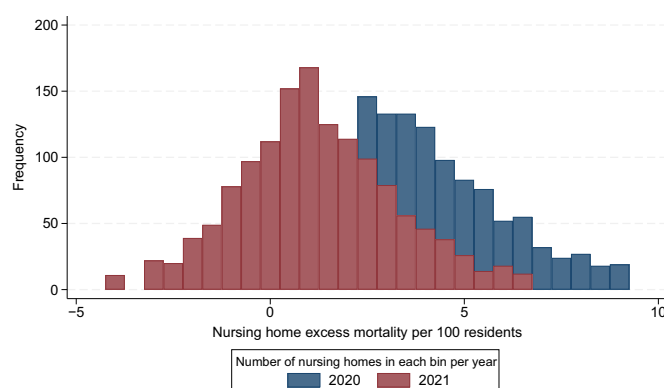


Fig. 1. Distribution of nursing home excess mortality estimates. The figure plots the distribution of excess mortality of all nursing homes per study year compared with their predicted mortality rate based on the characteristics of their residents. The estimates for each nursing home represent the best linear unbiased predictions obtained by equation (2) in Supplementary Material 1, adding average excess mortality, and multiplied by 100 for interpretation purposes. Bins that contain fewer than 10 nursing homes are excluded.

Relationship Between Excess Mortality and Nursing Home Characteristics

Most nursing home characteristics related to structure (Figure 2) were not or only weakly related to excess mortality in 2020 and 2021, with 2 exceptions. First, nursing homes who spent 4% (equal to 1 SD) of their salary expenses more on external staff, on average had 0.6 additional deaths per 100 residents in 2020. Second, nursing homes having a 1.2 percentage point higher absenteeism rate (equal to 1 SD) before the pandemic had on average 0.8 additional deaths per 100 residents in 2021.

Besides structure indicators, we examined the relationship between excess mortality and process indicators and online ratings separately (Figure 2). The results show no statistically or economically significant relationship between excess mortality and process indicators. The same holds for online ratings, except for the rating related to the accommodation: higher ratings on satisfaction with the accommodation are related to lower excess mortality in 2020.

Discussion

The COVID-19 pandemic was detrimental to people living in nursing homes. We observed the mortality probability among residents to be 34.0 and 31.6 per 100 residents in 2020 and 2021, which was considerably higher than the expectation based on prepandemic mortality of 30.4 to 30.5 per 100 residents. The COVID-19 death rate

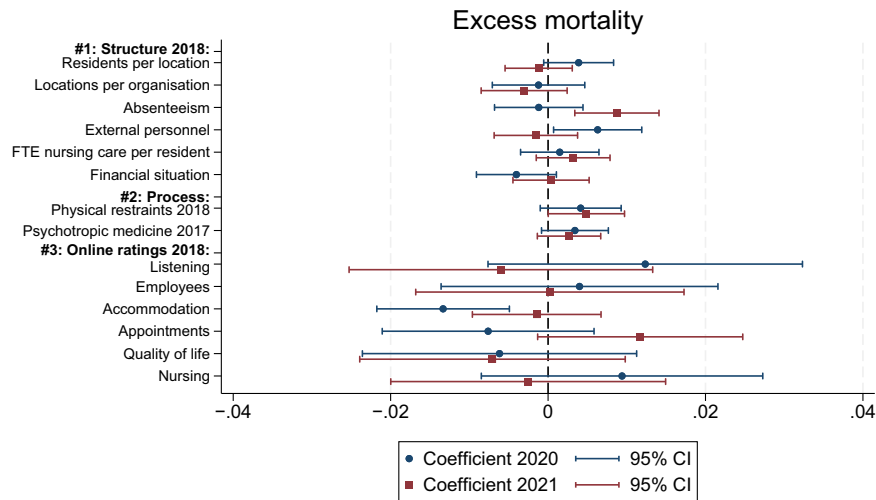


Fig. 2. Regression results excess mortality and nursing home characteristics by year. The figure plots the regression results of 3 separate regressions with excess mortality as an outcome and 3 sets of nursing home characteristics as explanatory variables. Estimated coefficients and 95% CIs are shown, which are both divided by the characteristic's SD to make the coefficients more comparable. All models include both region and nursing home-level random effects, and the characteristics are loaded on the nursing home level. FTE, full-time equivalent.

was substantially higher than these excess deaths. Moreover, this article documented wide variation in excess mortality during the pandemic across nursing homes after controlling for case-mix and regional differences: the 5% of the nursing homes with the highest excess mortality had 10 more excess deaths per 100 residents than the 5% with the lowest excess mortality.

These findings contribute to the existing evidence that was mainly based on variation in (COVID-19) death counts,^{3,6,8,12} differences in deaths between groups of nursing homes based on their characteristics,^{9,11} or excess mortality alone.²¹ By using a measure of excess mortality, and by comparing this to COVID-19 mortality in the same population of virtually all nursing home residents in the Netherlands, our results show that focusing on COVID-19 death counts can overestimate the pandemic's impact on total mortality of nursing home residents because part of the nursing home residents who died of COVID-19 would in the absence of the pandemic otherwise have died in the same year from another cause. Nonetheless, both excess mortality and its variation across the full range of nursing home providers were still substantially larger compared to prepandemic years, suggesting that the excess death rates during the COVID-19 pandemic did exacerbate preexisting mortality and its differences across nursing homes.

In addition, contributing to the mixed evidence on the relationship between mortality and nursing home characteristics during the COVID-19 pandemic,^{3,8} our findings showed no to only weak links with most of the characteristics. For instance, contrary to previous findings from Spain and the United States,^{3,9,11,12} we found no relationships between mortality and nursing home size or staffing levels. This contrast comes possibly from our focus on excess mortality instead of COVID-19 mortality or from nursing home facilities in the Netherlands generally being small. Similar to most other studies controlling for resident characteristics and regional differences across nursing homes,³ we find no strong relationship between excess mortality and most quality indicators. Nevertheless, we found statistically significant, though rather weak, relationships between excess mortality in 2020 and prepandemic spending on external personnel and dissatisfaction with the building, and between excess mortality in 2021 and prepandemic staff absenteeism.

We acknowledge 5 limitations. First, although our measure for excess mortality improves those used previously in the literature by accounting for detailed observed case-mix differences and regional variation,

unobserved differences may still exist. Nonetheless, prior evidence showed that case-mix corrections based on observables were unbiased at least to estimate the overall variation in mortality outcomes.²⁶ Second, similarly, even though we included a wide variety of nursing home and resident characteristics in our analysis, an unobserved component of nursing home quality, such as management quality, could explain the (lack of) relationships between those observed and excess mortality, particularly in the structure measures. Controlling for this would require an exogenous source of variation at the nursing home level,²⁷ which was beyond the scope of this research. Third, the quality ratings can be driven by various underlying dimensions (such as hygiene or state of the building) which makes it difficult to assess the exact meaning of these scores. Fourth, we only studied information on nursing home characteristics before the pandemic to not be concerned about reverse causality. However, possibly processes of care during the pandemic, such as isolation or vaccination strategies, were more strongly related to excess mortality as our findings highlight that a large part of variation in excess mortality across nursing homes remained unexplained. Fifth, the study was conducted in the Netherlands, which has a distinct long-term care system, meaning that not all results are easily generalizable. However, the main finding of this article, indicating the difference between measuring COVID deaths and excess mortality, is applicable to countries across the globe.

Conclusion and Implications

Our findings confirmed that the mortality rate among nursing home residents was higher than expected during the pandemic. Moreover, the COVID-19 death rate was substantially higher than excess deaths, indicating the importance of choice of measurement type. For example, the impact of the pandemic on nursing home inhabitants would seem more severe when reporting COVID-19 cases instead of excess mortality.

Additionally, we found wide variation in excess mortality during the pandemic across nursing homes. Although much of this variation in excess mortality remained unexplained, our results showed some relationships between prepandemic differences in accommodation quality or staff mobility. Hence, consideration could be given to designing guidelines that are applicable to various types of nursing home providers with different buildings and organization of

personnel. Finally, given that a large part of the variation in excess mortality remained unexplained, we recommend further investigating differences in processes of care during the pandemic, such as (appropriate) use of protective equipment and protocols during a COVID-19 outbreak or policies regarding infected staff members, to understand how optimizing these processes may help to mitigate the consequences of infectious disease outbreaks in the future.

Disclosures

The authors declare no conflicts of interest.

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Supplementary Data

Supplementary data related to this article can be found online at <https://doi.org/10.1016/j.jamda.2024.105116>.

References

- Blackman C, Farber S, Feifer RA, Mor V, White EM. An illustration of SARS-CoV-2 dissemination within a skilled nursing facility using heat maps. *J Am Geriatr Soc.* 2020;68:2174–2178.
- Van Den Besselaar JH, Sikkema RS, FMHPA Koene, et al. Are presymptomatic SARS-CoV-2 infections in nursing home residents unrecognised symptomatic infections? Sequence and metadata from weekly testing in an extensive nursing home outbreak. *Age Ageing.* 2021;50:1454–1463.
- Konetzka RT, White EM, Pralea A, Grabowski DC, Mor V. A systematic review of long-term care facility characteristics associated with COVID-19 outcomes. *J Am Geriatr Soc.* 2021;69:2766–2777.
- Panagiotou OA, Kosar CM, White EM, et al. Risk factors associated with all-cause 30-day mortality in nursing home residents with COVID-19. *JAMA Intern Med.* 2021;181:439–448.
- Schultze A, Nightingale E, Evans D, et al. Mortality among Care Home Residents in England during the first and second waves of the COVID-19 pandemic: an observational study of 4.3 million adults over the age of 65. *The Lancet Regional Health - Europe.* 2022;14:100295.
- Cronin CJ, Evans WN. Nursing home quality, COVID-19 deaths, and excess mortality. *J Health Econ.* 2022;82:102592.
- Stoeldraijer L, Kunst A, Chilunga F, Harmsen C. *Sociaal-Demografische Verschuiven in COVID-19-Sterfte in Het Eerste Jaar van de Coronapandemie.* Den Haag; 2022. Centraal Bureau voor de Statistiek.
- Dyer AH, Fallon A, Noonan C, et al. Managing the impact of COVID-19 in nursing homes and long-term care facilities: an update. *J Am Med Dir Assoc.* 2022;23:1590–1602.
- Costa-Font J, Jiménez Martín S, Viola A. Fatal underfunding? Explaining COVID-19 mortality in Spanish nursing homes. *J Aging Health.* 2021;33:607–617.
- Gorges RJ, Konetzka RT. Staffing levels and COVID-19 cases and outbreaks in U.S. Nursing homes. *J Am Geriatr Soc.* 2020;68:2462–2466.
- He M, Li Y, Fang F. Is there a link between nursing home reported quality and COVID-19 cases? Evidence from California skilled nursing facilities. *J Am Med Dir Assoc.* 2020;21:905–908.
- Iyanda AE, Boakye KA. A 2-year pandemic period analysis of facility and county-level characteristics of nursing home coronavirus deaths in the United States, January 1, 2020–December 18, 2021. *Geriatr Nurs.* 2022;44:237–244.
- Khairat S, Zalla LC, Adler-Milstein J, Kistler CEUS. Nursing home quality ratings associated with COVID-19 cases and deaths. *J Am Med Dir Assoc.* 2021;22:2021–2025.e1.
- Shen K, Loomer L, Abrams H, Grabowski DC, Gandhi A. Estimates of COVID-19 cases and deaths among nursing home residents not reported in federal data. *JAMA Netw Open.* 2021;4:e2122885.
- Wouterse B, Geisler J, Bär M, Van Doorslaer E. Has COVID-19 increased inequality in mortality by income in The Netherlands? *J Epidemiol Community Health.* 2023;77:244–251.
- Bielza R, Sanz J, Zambrana F, et al. Clinical characteristics, frailty, and mortality of residents with COVID-19 in nursing homes of a region of Madrid. *J Am Med Dir Assoc.* 2021;22:245–252.e2.
- Li Y, Temkin-Greener H, Shan G, Cai X. COVID-19 infections and deaths among Connecticut nursing home residents: facility correlates. *J Am Geriatr Soc.* 2020;68:1899–1906.
- McGarry BE, Gandhi AD, Grabowski DC, Barnett ML. Larger nursing home staff size linked to higher number of COVID-19 cases in 2020. *Health Aff.* 2021;40:1261–1269.
- Rutten JJS, van Loon AM, van Kooten J, et al. Clinical suspicion of COVID-19 in nursing home residents: symptoms and mortality risk factors. *J Am Med Dir Assoc.* 2020;21:1791–1797.e1.
- Unruh MA, Yun H, Zhang Y, Braun RT, Jung HY. Nursing home characteristics associated with COVID-19 deaths in Connecticut, New Jersey, and New York. *J Am Med Dir Assoc.* 2020;21:1001–1003.
- Tenso K, Strombotne KL, Feyman Y, Auty SG, Legler A, Griffith KN. Excess mortality at veterans health administration facilities during the COVID-19 pandemic. *Med Care.* 2023;61:456–461.
- Donabedian A. *An Introduction to Quality Assurance in Health Care.* Oxford: Oxford University Press; 2003.
- Sundararajan V, Henderson T, Perry C, Muggivan A, Quan H, Ghali WA. New ICD-10 version of the Charlson comorbidity index predicted in-hospital mortality. *J Clin Epidemiol.* 2004;57:1288–1294.
- Luque-Fernandez MA, Redondo-Sánchez D, Maringe C. *cvauroc: command to compute cross-validated area under the curve for ROC analysis after predictive modeling for binary outcomes.* *STATA J.* 2019;19:615–625.
- Siontis GCM, Tzoulaki I, Ioannidis JPA. Predicting death: an empirical evaluation of predictive tools for mortality. *Arch Intern Med.* 2011;171:1721–1726.
- Bär M, Bakx P, Wouterse B, van Doorslaer E. Estimating the health value added by nursing homes. *J Econ Behav Organ.* 2022;203:1–23.
- Konetzka RT, Yang F, Werner RM. Use of instrumental variables for endogenous treatment at the provider level. *Health Econ.* 2019;28:710–716.