



Covid-19 in the Community and Outbreaks in Long-Term Residential Care in Ireland

RESEARCH

BRENDAN WALSH 

SHEELAH CONNOLLY 

MAEV-ANN WREN 

*Author affiliations can be found in the back matter of this article



ABSTRACT

Context: Long-term residential care (LTRC) has been disproportionately impacted by Covid-19, with two-thirds of Covid-19 deaths occurring in LTRC homes in Ireland.

Objectives: The study aims to examine the factors associated with LTRC Covid-19 outbreaks in Ireland.

Methods: We merged data on Covid-19 cases and deaths in the community and LTRC homes with LTRC home characteristics across Waves 1-3 of the pandemic. Analyses examined the impact LTRC home characteristics and proximity to high community Covid-19 rates had on the likelihood of Covid-19 outbreaks and severity of outbreaks in LTRC homes.

Findings: 8,502 confirmed cases of Covid-19 among LTRC home residents were recorded. Two thirds of LTRC homes had a Covid-19 outbreak across the first three waves of the pandemic. Larger LTRC homes were three times more likely to have an outbreak than smaller homes. High local community Covid-19 rates significantly increased the probability of a LTRC home outbreak. Homes in areas with the highest community Covid-19 rates were almost seven times more likely to have an outbreak than LTRC homes located in areas with the lowest community Covid-19 rates.

Limitations: No centralised dataset exists in Ireland that collects information on morbidity, dementia or cognitive status of had on residents.

Implications: Covid-19 had a significant impact on LTRC in Ireland with very high rates of cases and deaths. Our findings suggest that while factors such as home size may have increased the probability of an outbreak, being located in areas with high levels of community Covid-19 cases was likely the key factor explaining LTRC outbreaks.

CORRESPONDING AUTHOR:

Brendan Walsh

Economic and Social Research
Institute, IE

brendan.walsh@esri.ie

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INTRODUCTION

Long-term residential care (LTRC) homes are at the centre of the Covid-19 pandemic. In many countries, Covid-19 deaths in LTRC residents accounted for more than half of all such deaths (Comas-Herrera et al., 2021). Death rates among LTRC residents were much higher than for similarly aged people living in the community (Dutey-Magni et al., 2021).

A large international literature has identified a number of factors associated with Covid-19 outbreaks in LTRC settings including facility size, form of ownership and community rates of Covid-19 (Konetzka et al., 2021; Frazer et al., 2021). Larger LTRC homes (Aalto et al., 2022; Konetzka et al., 2021) and homes with higher rates of occupancy (Dutey-Magni et al., 2021; Torres et al., 2022) have been found to have more Covid-19 outbreaks and higher Covid-19 mortality rates. Although the probability of an outbreak increased with the size of the facility, higher nurse-resident ratios were shown to reduce spread of Covid-19 infection once it entered a facility (Dutey-Magni et al., 2021; Figueroa et al., 2020). A large number of studies have examined whether LTRC ownership, specifically for-profit status, is associated with worse Covid-19 outcomes, with somewhat mixed results. Evidence from the UK found that excess deaths per bed were much higher in not-for-profit LTRC homes (Morciano et al., 2021). However, in countries including Canada, for-profit providers had higher rates of cases, longer outbreak length, and higher mortality compared to not-for-profit homes (Stall et al., 2020). Reviewing the literature, studies noted that while in general, for-profit status may be correlated with higher rates of LTRC Covid-19 outbreaks and mortality (Bach-Mortensen et al., 2021), this association was attenuated when other factors, including size, staff shortages, and especially community Covid-19 rates, were controlled for (Kruse et al., 2021). High rates of Covid-19 in the community where LTRC homes are located is arguably the largest predictor of outbreaks and severity of outbreaks within LTRC (Aalto et al., 2022). Across a range of countries, Covid-19 incidence rates in communities surrounding LTRC homes (Brown et al., 2020; HIQA and HPSC, 2022; Shallcross et al., 2021; Stall et al., 2020; White et al., 2020) or in communities where LTRC staff reside (Shen, 2022) were identified as the most significant risk factors for LTRC home outbreaks. Previous research into LTRC outbreaks also found that studies that failed to control for community Covid-19 rates were likely confounded (Konetzka et al., 2021).

Ireland has had one of the highest concentrations of Covid-19 deaths in LTRC residents. Throughout the first waves of the pandemic, 66% of all Covid-19 deaths were related to outbreaks in LTRC (HIQA and HPSC, 2022). This places Ireland second only to Australia (75%) in terms of the percentage of deaths from Covid-19 linked to LTRC (Comas-Herrera et al., 2021) (though community rates

were much higher in Ireland than Australia) and higher than countries such as Canada (59%) and Belgium (57%), which are often highlighted as having high rates of Covid-19 in LTRC (Comas-Herrera et al., 2021). Despite the disproportionate impact of Covid-19 on LTRC residents in Ireland, relatively little research has examined the factors associated with LTRC Covid-19 outbreaks and deaths. The high concentration of deaths from Covid-19 in LTRC facilities and the dominance of private provision of LTRC make an analysis of Covid-19 outcomes in LTRC homes in Ireland important in an international context. Despite the fact that LTRC is predominantly funded by the state, over 80% of LTRC is now provided by the private sector (HIQA and HPSC, 2022). In the early months of the pandemic, much emphasis was placed on privately provided LTRC homes, with the assumption that such homes had poorer Covid-19 outcomes relative to publicly provided homes. However, the evidence to date does not support these claims, with community Covid-19 rates and LTRC home size being key factors in LTRC outbreaks (HIQA and HPSC, 2022). Consequently, the aim of this study is to examine the factors associated with Covid-19 outbreaks and outbreak severity in LTRC homes in Ireland across the first three waves of the pandemic, including the form of ownership.

METHODS

STUDY POPULATION AND DATA

As there is no single dataset that includes data on the characteristics of LTRC homes and Covid-19 outbreaks, it was necessary to match two existing datasets – one on Covid-19 in LTRC and non-LTRC settings, collected by the Health Protection and Surveillance Centre (HPSC) and another on home characteristics, collected by the Health Information and Quality Authority (HIQA – the regulator of LTRC). The datasets were matched using LTRC ID, date, and county which were consistent across datasets. The analyses were carried out on all 572 LTRC homes registered with HIQA as designated centres for older people, who consistently provided care between March 2020 and March 2021.

The HPSC data includes LTRC and non-LTRC Covid-19 cases and deaths from 1 March 2020 to 31 March 2021 and captures information on outbreak ID, date of the first and last notified Covid-19 confirmed case, number of cases and deaths (partitioned by residents and healthcare workers), and hospitalisations. The length of an outbreak was determined from the date of the first confirmed case to 14 days after the last confirmed Covid-19 case. A small number of outbreaks recorded as separate outbreaks, but where beginning and end dates intersected, were merged for this analysis. The non-LTRC Covid-19 data collected by the HPSC capture daily confirmed cases and deaths for each county. We estimated community Covid-19 rates by subtracting LTRC cases from total cases and dividing community

cases by population within each county in 2020 using data from the Central Statistics Office (CSO).¹ HIQA data captures information on location, provider type (public or private), owner, and size (number of beds in facility in March 2020), and importantly includes LTRC homes that did not experience any Covid-19 outbreaks.

STATISTICAL ANALYSES

The probability of a Covid-19 outbreak and the severity of an outbreak (percentage of residents infected and Covid-19 death rates) were examined in this analysis. An outbreak was defined by the HPSC if there were two or more laboratory-confirmed Covid-19 cases, regardless of symptomatic presentation, and/or two or more illness cases with symptoms consistent with Covid-19 infection where one person is a confirmed case. Within the analyses, we created a binary outbreak variable capturing the presence of an open outbreak for each date within the study period.

Although the HPSC data capture information on confirmed Covid-19 cases and deaths for healthcare worker and resident cases (defined as cases occurring in people aged 65+), in this analysis only resident cases and deaths are included. To capture severity of an outbreak, we estimated the relative size of, and mortality associated with, an outbreak. The size of an outbreak is estimated as the total number of confirmed resident cases divided by the number of beds in a LTRC home. Covid-19 mortality was estimated as the total number of confirmed deaths from Covid-19 divided by LTRC home bed capacity. Although information on the number of residents at each point in time in a LTRC home is not available, previous research has shown occupancy in LTRC homes in Ireland averages 94% (Wren et al., 2017), making bed capacity a good approximate of the number of residents. Analyses were carried out at the LTRC home-day level (572 homes across 396 days; $N = 226,512$), allowing this study to examine time-varying characteristics such as community Covid-19 rates in the locality of the LTRC homes.

The first outcome variable of interest is the probability of a Covid-19 outbreak in a LTRC home. To examine this outcome, we created a binary variable that indicates whether a Covid-19 outbreak started in a LTRC home, for each day during the study period (1 March 2020–31 March 2021). As the probability of a Covid-19 outbreak variable is binary, we used logistic regression in our analyses. We also created a second binary variable to capture the days in which LTRC homes had an ongoing outbreak. This variable was used to exclude LTRC homes from the analyses on those days that corresponded to their open outbreak.

The other outcome variables of interest relate to the severity of a Covid-19 outbreak. In this study, we measured the severity of an outbreak both as the percentage of residents with a confirmed Covid-19 diagnosis and the percentage of residents who died of Covid-19. As both

of these variables are measured as percentages, and their values are bounded between 0% and 100%, both linear regression and Beta regressions were deemed inappropriate (Hardin and Hilbe, 2007; Papke and Wooldridge, 1996). Fractional rank regressions were deemed the most appropriate statistical approach to use based upon previous analysis in the literature (Coe et al., 2015). Generalised linear models (GLM) with logistic link functions and binomial distribution were estimated with results presented as percentage point differences (average marginal effects).

The key exposure variable examined was Covid-19 rates in the community. Daily confirmed Covid-19 cases per 10,000 population within each of the 26 counties in Ireland (total cases minus cases confirmed in LTRC) were matched with LTRC homes within each county. One complication of this exposure variable is that Covid-19 case numbers are closely related to testing availability and testing guidance, which differed over time. To circumvent these issues, we created a wave-specific variable of community Covid-19 rates. This variable captured relative size of community Covid-19 rates separately for each county-day for Waves 1 (1 March 2020–1 August 2020), 2 (2 August 2020–21 November 2020), and 3 (22 November 2020–31 March 2021), respectively. The dates of each wave correspond to the dates outlined by the HPSC (HIQA and HPSC, 2022). This variable was further split into quintiles (20%) when included in our regressions to aid interpretation of results. Evidence also points to LTRC home outbreaks lagging outbreaks within the surrounding communities (Malikov et al., 2021). Therefore, within our analyses examining the probability of a LTRC outbreak on a given day t , average community Covid-19 rates in the previous seven days ($t-7 - t-1$) were included. Additionally, as outbreak severity may be a function of high community Covid-19 rates both before and after an outbreak begins, analyses examining the severity of a LTRC outbreak, average community Covid-19 rates in the previous 7 days ($t-7 - t-1$) and the 14 days following an outbreak ($t - t+13$) were included. The results were robust to different specifications of community Covid-19 rates.

The regression analyses included a number of other factors including home size, location, and ownership. In the analyses, LTRC homes were included as being owned and run by the Health Service Executive (HSE – the provider of public health and social care in Ireland) or not (private). In our results we focus on ownership and whether community Covid-19 rates impacted Covid-19 outbreaks in public and private homes differently. Owing to considerable temporal changes in Covid-19 during the period of analyses, including knowledge about prevention and treatment of Covid-19, readiness of LTRC homes, Covid-19 variant changes, and vaccination availability, wave fixed effects in each wave were included. In addition, analyses were also conducted separately for each wave (Wave 2 was relatively small in Ireland; we combine Waves 1 and 2), with results presented in

the Appendix. Across all models, standard errors were clustered at the LTRC home level.

ETHICS

The analyses used anonymised data aggregated at the unit level (LTRC home) and therefore ethical approval was not required.

RESULTS

DESCRIPTIVE RESULTS

Overall, 65% of all LTRC homes had at least one outbreak in Waves 1–3 of the pandemic (Table 1). Among the 545 separate outbreaks reported, there were 8,502 confirmed Covid-19 cases and 2,107 Covid-19 deaths among LTRC residents. In total, 24.7% of residents who were confirmed

	ALL	PUBLIC (HSE)	PRIVATE (NON-HSE)
LTRC Home Characteristics			
Total LTRC Homes in Sample	572	113	459
Total LTRC Beds in Sample	31,932	5,349	26,583
LTRC Home Size			
Small (<40 beds)	32.5%	50.4%	28.1%
Medium (40–59)	31.3%	20.4%	34.0%
Large (60+)	36.2%	29.2%	37.9%
LTRC Covid-19 Descriptive Statistics			
Outbreaks (n)	545	106	439
Outbreaks Wave 1	238	45	193
Outbreaks Wave 2	87	20	67
Outbreaks Wave 3	220	41	179
Outbreak (%)	64.9%	65.5%	64.7%
Outbreak Wave 1	44.2%	42.5%	44.7%
Outbreak Wave 2	7.2%	10.6%	6.3%
Outbreak Wave 3	32.0%	32.7%	31.8%
Cases ^a	15,511	2,788	12,723
Resident Cases	8,502	1,291	7,211
HCW Cases	6,092	1,315	4,777
Resident Deaths	2,107	296	1,811
Resident Deaths Wave 1	1,039	143	896
Resident Deaths Wave 2	172	26	146
Resident Deaths Wave 3	896	127	769
Number of Outbreaks (if Outbreak)	1.5	1.4	1.5
Average Length of Outbreak	34.9 days	33.6 days	35.3 days
Average Length of Outbreak Wave 1	36.1 days	36.7 days	36.0 days
Average Length of Outbreak Wave 2	24.3 days	31.9 days	21.2 days
Average Length of Outbreak Wave 3	35.4 days	29.7 days	36.9 days
Average Resident Cases	22.9	17.4	24.7
Average Resident Cases per Bed	0.372	0.328	0.383
Resident Deaths per Case	24.7%	22.9%	25.1%
Resident Deaths per Case Wave 1	27.4%	22.7%	28.4%
Resident Deaths per Case Wave 2	17.6%	16.8%	17.8%
Resident Deaths per Case Wave 3	23.9%	25.0%	23.8%

Table 1 Descriptive Statistics of LTRC Covid-19 Outbreaks in Ireland, 1 March 2020–31 March 31 2021.

Notes: ^a Cases include Covid-19 cases amongst LTRC residents, healthcare workers, and a small number of other linked cases.

to have Covid-19 died of the disease. Appendix Figure A1 shows that large spikes occurred in Waves 1 and 3, but the beginning of the vaccination of LTRCs from January 2021 coincided with a sharp reduction in outbreaks.

LTRC OUTBREAKS

Figure 1 shows the association between LTRC home Covid-19 outbreaks and LTRC home characteristics. Larger homes (60+ beds) were 3.5 times more likely to have a Covid-19 outbreak compared to smaller homes (<40 beds). In addition, Appendix Figure A2 shows that larger LTRC homes also had 2.5 more outbreaks on average across the period of study compared to smaller homes. No difference in the probability of an outbreak was observed between public and private LTRC homes.

Being located within a county with high community Covid-19 rates was found to have the largest association with the probability of a Covid-19 outbreak. The odds of having an outbreak in a LTRC home located in the highest quintile of community Covid-19 rates were almost seven

times higher (Odds Ratio [OR] = 6.8; 95% CI: 4.6–10.1) than in the lowest quintile. Results in the Appendix Figure A3 also highlight that in Wave 3, the odds of having an outbreak in a LTRC home located in the highest quintile of community Covid-19 rates were 10.7 times higher (95% CI: 5.8–19.6).

To emphasize the magnitude of these effects, Table 2 provides predicted probabilities of a LTRC home experiencing a Covid-19 outbreak, measured at a daily level, across local community Covid-19 rate quintiles. The daily probability that a LTRC home located in the highest quintile of community Covid-19 rates had an outbreak was 0.6%, rising to 0.9% in Wave 3. In Wave 3, these probabilities equate to a one in eight chance of a LTRC home Covid-19 outbreak in a two-week period in quintile 5, compared to a one in 80 chance in quintile 1.

Figure 2 shows whether higher community Covid-19 rates had differential impacts on public or private, and smaller or larger, LTRC homes. No differences are observed across ownership type. However, heterogenous

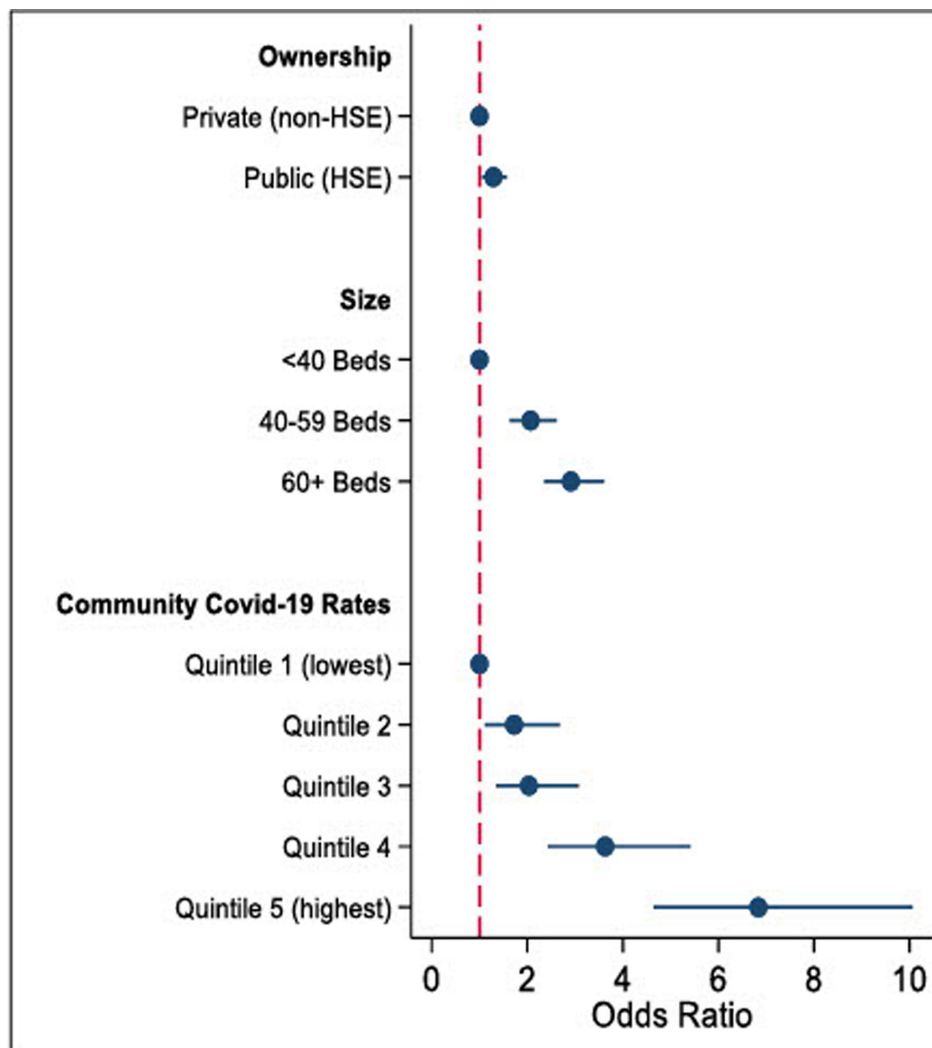


Figure 1 LTRC Covid-19 Outbreaks: Ireland, 1 March 2020–31 March 2021.

Notes: Logistic regression at the LTRC home-day level ($n = 208,123$); Community Covid-19 rates represent average cases per 10,000 population in preceding 7 days in county where LTRC homes is located; LTRC homes removed from analysis if experiencing an open outbreak; Standard errors clustered at the LTRC home level.

	ALL WAVES 1–3	WAVE 1	WAVE 2	WAVE 3
Community Covid-19 Rates				
Quintile 1 (lowest)	0.09%	0.13%	0.05%	0.09%
Quintile 2	0.15%	0.16%	0.11%	0.24%
Quintile 3	0.18%	0.21%	0.16%	0.19%
Quintile 4	0.32%	0.53%	0.15%	0.39%
Quintile 5 (highest)	0.61%	0.67%	0.27%	0.90%

Table 2 Probability of a LTRC Covid-19 Outbreak (Daily): Ireland, 1 March 2020–31 March 2021.

Notes: Predicted probability of a Covid-19 outbreak following logistic regression at the LTRC home-day level ($n = 208,123$). Community Covid-19 rates represent average cases per 10,000 population in the preceding seven days in the county where the LTRC home is located. LTRC homes were removed from the analysis if they experienced an open outbreak. Standard errors clustered at the LTRC home level.

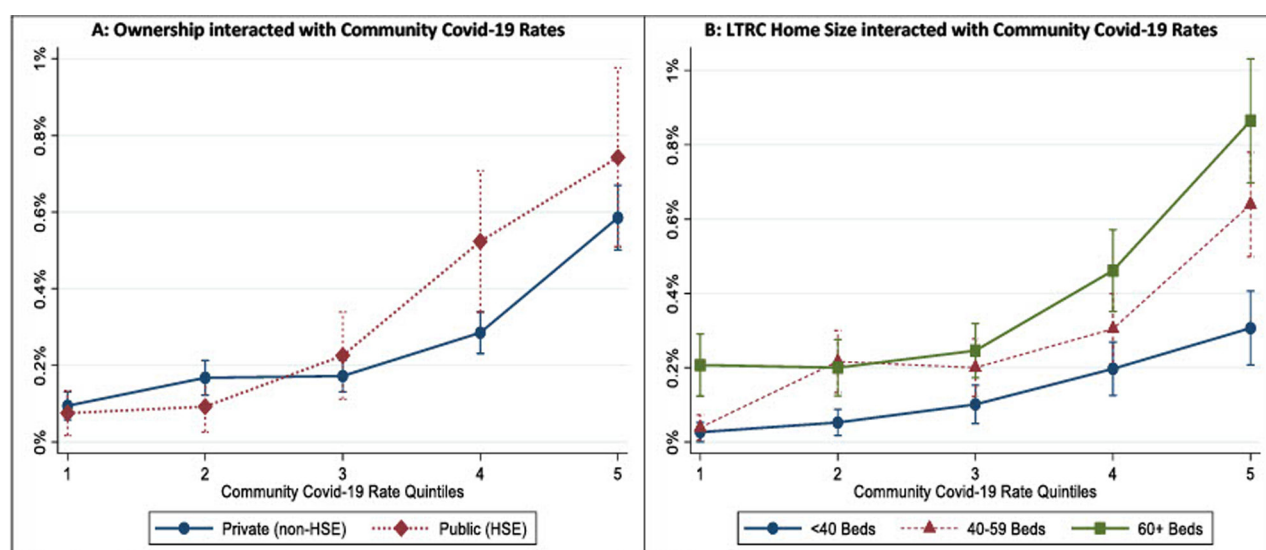


Figure 2 LTRC Covid-19 Outbreaks, Interaction Plots: Ireland, 1 March 2020–31 March 2021.

Notes: Predicted probability of a Covid-19 outbreak following logistic at the LTRC home-day level ($n = 208,123$); Community Covid-19 rates represent average cases per 10,000 population in preceding 7 days in county where LTRC home is located; Standard errors clustered at the LTRC home level.

effects are observed across LTRC homes of different sizes. Community Covid-19 rates had much greater effects on larger LTRC homes. The daily probability of an outbreak in larger LTRC homes located in quintile 5 was 0.9%, compared to 0.3% in smaller LTRC homes, equating to a one in eight chance of a LTRC home Covid-19 outbreak in a two-week period in a large home, compared to a one in 23 chance in a small home.

LTRC OUTBREAK SEVERITY

Figure 3 shows the severity of LTRC outbreaks, as assessed by the size of the outbreak (Panel A) and deaths (Panel B). In absolute terms, larger LTRC homes had more people infected during an outbreak, but the relative size of outbreaks (percentage of residents infected) in larger LTRC homes was less than in smaller LTRC homes (-13.8 percentage points (pp); 95%CI: -6.9 pp – -20.7 pp). Community Covid-19 rates were positively associated

with larger outbreaks. The result is mainly driven by differences between quintile 1 and the other quintiles. LTRC homes in quintile 5 had more infections among residents compared to homes in quintile 1 (12.9pp; 95%CI: 2.8pp–23.0pp).

A lower percentage of residents (-3.1 pp; 95% CI: -0.8 pp – -5.5 pp) in larger LTRC homes died from Covid-19 compared to smaller LTRC homes with <40 beds. Again, local Covid-19 rates were positively associated with higher rates of Covid-19 deaths within LTRC home outbreaks. However, the effect of community Covid-19 rates was mainly driven by differences between quintile 1 and the other quintiles. More residents died from Covid-19 (4.4pp; 95% CI: 1.8pp–7.0pp) in LTRC homes with an outbreak in quintile 5, compared to homes in quintile 1. Results were once again much larger in Wave 3 (Appendix Figure A4).

An additional analysis of the severity of an outbreak was conducted, which examined Covid-19 deaths per

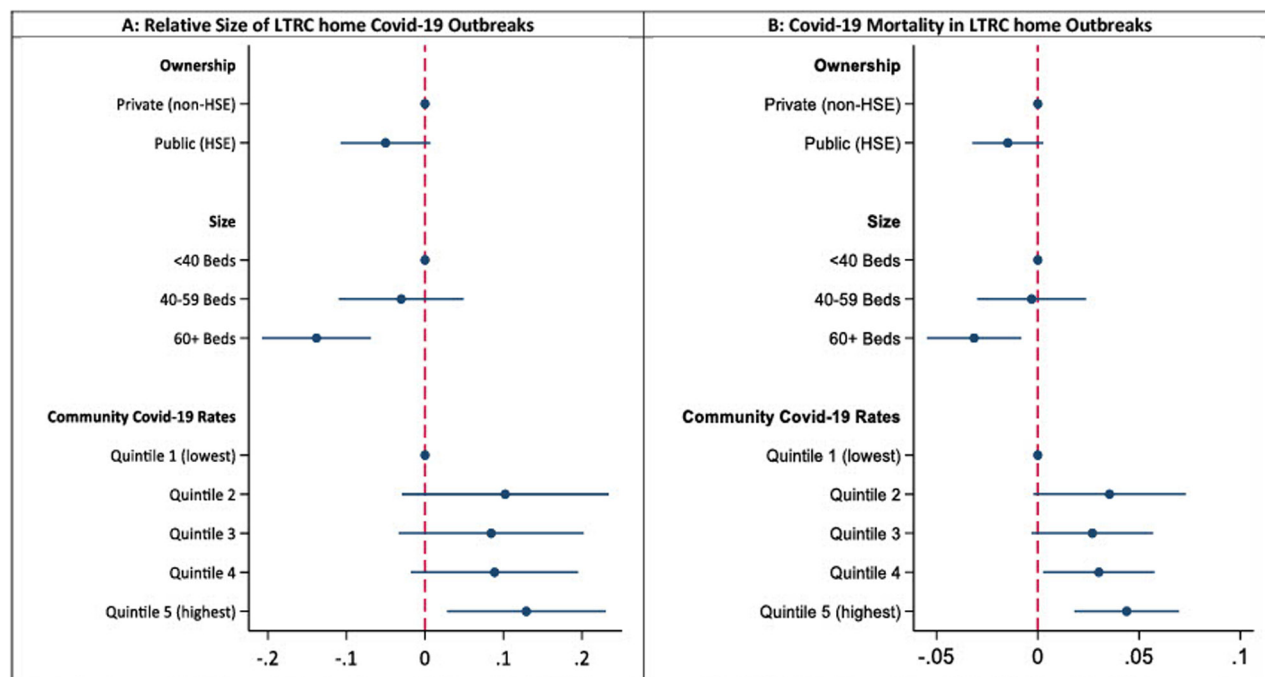


Figure 3 LTRC Covid-19 Outbreak Severity: Ireland, 1 March 2020–31 March 2021.

Notes: Percentage point difference following Generalized Linear Model (GLM) regressions with logistic link function and binomial distribution at the LTRC home-outbreak level ($n = 545$); Community Covid-19 rates represent average cases per 10,000 population in preceding 7 days, and 14 days (21 days in total) following the start of an outbreak, in county where LTRC home is located; Standard errors clustered at the LTRC home level.

confirmed resident case (Appendix Figure A5). Similar results were found, showing no statistically significant difference in Covid-19 mortality per confirmed resident case across ownership type. However, higher community Covid-19 rates were once again associated with higher mortality using this alternative measure.

In addition, Appendix Figure A6 presents an analysis examining whether community Covid-19 rates had differing impacts on the severity of outbreaks across public and private LTRC homes. However, no heterogeneous effects across ownership type were observed.

DISCUSSION

In this analysis, community rates of Covid-19 were found to be the key determinant of Covid-19 outbreaks in LTRC homes in Ireland, with homes located in counties with the highest community Covid-19 rates were almost seven times more likely to have a Covid-19 outbreak than homes located in counties with the lowest community Covid-19 rates. The large effects of community Covid-19 rates were observed in both public and private LTRC homes. These results are in line with national (HIQA and HPSC, 2022) and international evidence showing that Covid-19 rates in the community were the largest determinant of a Covid-19 outbreak in LTRC (Aalto et al., 2022; Brown et al., 2020; Shallcross et al., 2021; Stall et al., 2020; White et al., 2020).

Community Covid-19 rates were also associated with more severe outbreaks, both in terms of relative size and Covid-19 mortality rates. Outbreaks in homes

with the highest community Covid-19 rates were 13 percentage points larger than outbreaks that occurred in LTRC homes with the lowest community Covid-19 rates. Similarly, Covid-19 mortality rates in homes with the highest community Covid-19 rates were more than 4 percentage points higher compared to homes located in counties where the community Covid-19 rates were lowest. However, the impact of community Covid-19 rates did not increase across quintiles, but rather was mainly driven by differences between quintile 1 and the other quintiles. This suggests that even when outbreaks occurred, low community rates of Covid-19 significantly reduced spread within a LTRC home. Policies designed to reduce the impact of Covid-19 and other infectious diseases such as influenza in LTRC homes therefore should also focus on such diseases in the community, vaccination for such disease, and increase awareness amongst staff and family members around reducing spread into LTRC homes.

Supporting previous evidence (Aalto et al., 2022; Konetzka et al., 2021), the size of a LTRC home was strongly associated with Covid-19 outbreaks. Larger homes were 3.5 times more likely to have a Covid-19 outbreak compared to smaller homes, and also reported a larger number of outbreaks on average (2.5 vs. 1). Examining the interaction effects of community Covid-19 rates and the size of a LTRC home, there is evidence that the size of a LTRC home, measured as number of beds or residents, may have exacerbated the effect of community Covid-19 rates on the probability of an outbreak occurring. The daily probability of an outbreak in larger LTRC homes located in counties where community Covid-19 rates were highest

was 0.9%, compared to 0.3% in smaller LTRC homes. While larger LTRC homes have more Covid-19 cases and deaths in absolute terms, the relative size and Covid-19 mortality rate was lower in larger LTRC homes. These results may be partly explained by larger LTRC homes comprising multiple wings or buildings, which may help to reduce infection across residents. Designs of future LTRC homes, especially larger homes, should factor in designs to reduce infection spread across residents.

In keeping with the much of the international literature (Bach-Mortensen et al., 2021; Kruse et al., 2021), no statistically significant differences in the probability of a Covid-19 outbreak and the severity of outbreaks according to ownership type (private versus public) were found.

LIMITATIONS OF THE STUDY

There is no centralised dataset in Ireland that collects information on morbidity, dementia, or cognitive status of residents. Therefore, we were unable to examine the impact resident-level characteristics had on Covid-19 outcomes. There is no dataset that collects information on staffing levels, staffing mixes, or physical facilities including single room occupancy, communal facilities, or isolation facilities. Consequently, it was not possible to examine how such factors impacted Covid-19 outcomes. Data availability limited the analysis from capturing the impact of the Covid-19 vaccination rollout on Covid-19 in LTRC homes. The number of beds in a LTRC home was used as a proxy for the number of residents in our analysis that examined the severity of an outbreak. Although occupancy rates may have fluctuated both between and within LTRC homes during the study period, there are no longitudinal data available to capture these changes. Nonetheless, the sensitivity analyses that measure outbreak severity as Covid-19 deaths per confirmed case (Figure A5) yielded similar results to those presented in the main analyses.

CONCLUSIONS

Covid-19 has had a devastating impact on the LTRC sector in both Ireland and internationally. A better understanding of the factors associated with Covid-19 outbreaks and severity within the sector can provide valuable lessons on how the impact of future waves of Covid-19 or other infectious diseases can be mitigated. While various measures implemented in Ireland and elsewhere (including lockdowns, the provision of PPE, etc.), in particular the implementation of the vaccination programme, reduced the impact of the pandemic both within and outside of LTRC homes, outbreaks continue to impact the LTRC sector. This analysis highlights the association between Covid-19 rates in the community and outbreaks in LTRC settings and points to the need

to keep community levels of Covid-19 low in order to protect LTRC residents.

NOTE

1 <https://www.cso.ie/en/releasesandpublications/fp/fp-ipeads/irishpopulationestimatesfromadministrativedatasources2020/populationestimates/>.

ADDITIONAL FILE

The additional file for this article can be found as follows:

- **Supplementary Appendix.** Appendix includes 6 additional figures. DOI: <https://doi.org/10.31389/jltc.191.s1>

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COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR AFFILIATIONS

Brendan Walsh  orcid.org/0000-0001-6230-0496
Economic and Social Research Institute, IE; Trinity College Dublin, IE

Sheelah Connolly  orcid.org/0000-0002-8539-6424
Economic and Social Research Institute, IE; Trinity College Dublin, IE

Maev-Ann Wren  orcid.org/0000-0003-4026-0344
Economic and Social Research Institute, IE; Geary Institute, University College Dublin, IE

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