INTRODUCTION

The devastating mortality recorded among residents of nursing homes across the world was not expected when a new, novel strain of coronavirus, SARS-CoV-2, emerged in Wuhan, China, during December 2019. The potential of a global pandemic needing concerted emergency management responses and the high case-fatality rates (CFRs) disproportionately affecting older people with multiple co-morbidities (14.8%-20.2%) compared to general population (2.3%-7.2%) were known by March 2020.1

As of March 2021, 119 million people had been infected with 2.6 million deaths from COVID-19 across 192 countries.2 Residents of nursing homes comprise half (47%) of all deaths from COVID-19 infection across the world.3 Concerns about this disproportionate effect has led to separate inquiries in multiple countries including Australia,4 Canada5 and England,6 with 22,287 deaths in care home residents (45% of total deaths) and outbreaks occurring in 6,811 of 15,476 (44%) care homes.3

Prevention and harm reduction require a better understanding of the underlying factors contributing to nursing homes’ risk of an occurrence of a COVID-19 outbreak, likelihood of a large outbreak and resident mortality. This requires extending the conceptual model and analysis beyond the traditional infectious disease triad of infectious agent, host and transmission:
• SARS-CoV-2 is the coronavirus pathogen responsible for COVID-19. It is thought to spread through droplet, aerosol, airborne and possibly faecal-oral routes, and is highly transmissible, with an estimated acute reproduction number ($R_0$) of 1.8-3.6.\(^7\)

• Host factors associated with poor prognosis and higher CFR from COVID-19 infection include frailty, older age and the presence of specific and multiple co-morbidities.\(^7\)

• Factors enhancing transmission are related to individuals’ behaviours and the built environment. Behaviours such as physical distancing, wearing masks and hand hygiene are more difficult for people with cognitive impairment and dementia, conditions affecting approximately half of nursing home residents.\(^8\) The built environment of nursing homes facilitates transmission through communal facilities, including shared living spaces and bathrooms, difficulty physically distancing as close contact is required between residents and staff to deliver personal care, and staff movement between multiple residents.\(^8\)

Beyond the built environment of a nursing home is the organisation's system for providing care: broadly including governance (eg presence of a board), workforce (eg chief executive officer (CEO) with clinical qualifications), models of care (eg ownership, number of residents), evaluation and use of data (eg regulatory sanctions), and resources and infrastructure (eg number of facilities operated by a provider).\(^9\)\(^-\)\(^13\) The variation in outcomes experienced by nursing homes in similar regions may be due to differences in these organisational characteristics.

The extent and nature of support the acute health system provides to a nursing home could also influence resident mortality. The hospital's capacity for an early transfer of a resident may have dual benefits by reducing a source of transmission in the nursing home and optimising clinical care for the resident.

1.1 | Aim

To determine nursing home characteristics—including organisational and facility structures, location and access to acute health care—associated with COVID-19 outbreak, outbreak size and resident mortality, during the second wave of the pandemic in Victoria, Australia.

2 | METHODS

2.1 | Study design

We conducted a population-based cross-sectional study of all nursing homes in Victoria, Australia's second most populous jurisdiction, between 7 July and 13 November, which is when a second wave of COVID-19 was experienced. COVID-19 outbreak was first reported in a Victorian nursing home on 7 July,\(^14\) and the data were analysed in November 2020 after the second wave had abated. All data were obtained from the following publicly available sources:

1. Commonwealth Department of Health Public Health Events Surveillance System (PHESS) data, including number of nursing homes with COVID-19 cases, and deaths among residents who died in the nursing home or hospital.\(^15\)

2. Australian Institute of Health and Welfare data, including the nursing home provider by type of ownership, number of facilities operated, number of beds and number of shared rooms in each home and government funding per bed.\(^16\)

3. Australian Aged Care Quality and Safety Commission (ACQSC) data on any non-compliance or sanctions imposed on the nursing home by the regulator.\(^17\)

4. Australian Bureau of Statistics data describing the socio-economic status of nursing homes according to postcode and geographic remoteness by the Modified Monash Model (MMM).\(^18\)

5. ‘Farm Transparency Project’ data used to identify the location of abattoirs.\(^19\)

6. The nursing home’s website to identify whether the nursing home had a board of governance and the incumbent CEO.

7. LinkedIn, to identify whether the CEO had professional qualifications in a clinical discipline.

2.2 | Setting

The study was conducted in Victoria, which, in 2020, had a population of approximately 6.7 million people, of which 1 054 741 (15.8%) were aged 65 or older.\(^20\)

2.3 | Participants

Victoria had 766 accredited residential aged care services as at June 2020, accommodating 48 824 permanent residents.\(^16\)

Policy Impact

This article examines facility-level characteristics of nursing homes associated with outbreak, outbreak size and mortality in the second wave of COVID-19 in Victoria, using publicly available information. Understanding such characteristics can inform risk management, prioritising emergency responses and optimising future nursing home operations.
To be eligible for inclusion in this study, nursing homes had to have been accredited by ACQSC, with a COVID-19 case diagnosed between 7 July and 13 November 2020.

2.4 | Outcome variables

The primary outcomes were intrusion by SARS-CoV-2 into a nursing home (at least one resident case), the cumulative incidence of COVID-19 cases reported by the government public health unit and mortality per 100 residents.

The criteria applied to determining what constitutes a COVID-19 death differs between countries resulting in substantive variations in reporting. In Victoria, and in our study, residents with confirmed COVID-19 are diagnosed on the basis of either: testing positive to a validated specific SARS-CoV-2 nucleic acid test; isolation of the virus in cell culture, with PCR confirmation using a validated method, or seroconversion to, or significant rise in, SARS-CoV-2 neutralising or IgG antibody level.

Size of an outbreak was defined as small, medium and large (1-5, 6-10 and 11+ cases per 100 residents, respectively). The assumption underlying the scale of the outbreak is that each category of outbreak represents a substantial increase in the nursing and care workload.

2.5 | Predictor variables

We examined:

- four provider characteristics: (V-1) ownership of the facility (private, not-for-profit or, public-sector), (V-2) number of separate facilities the provider operated (1, 2-10 and 11+ facilities), (V-3) whether a board of governance was in place and (V-4) whether the CEO had a clinical qualification

- three facility characteristics: (V-5) size of the facility (number of beds), (V-6) proportion of 1-bed or multiple-bed rooms and (V-7) history of regulatory non-compliance

- three geographic characteristics according to facility location: (V-8) MMM remoteness, (V-9) socio-economic status and (V-10) proximity to high-risk industry (abattoirs)

- two acute hospital characteristics: (V-11) facility proximity to an acute public hospital and (V-12) the size of that hospital

A clinical qualification was defined as a university degree required for a professional to be directly involved in delivering medical, nursing or allied health care.

Predictor variables were extracted only from data reported prior to July 2020.

2.6 | Data sources and measurement

Each variable of interest, sources of data, and grouping or categories used in the analysis are described in Table S4.

2.7 | Study size

The study included the whole population of nursing homes in Victoria, Australia (n = 766), with a subgroup of nursing homes (n = 74) with at least one confirmed case of COVID-19 involving a resident.

2.8 | Statistical methods

All analyses were conducted using Stata 16. $r \times c$ chi-square tests were used to examine for differences in proportions between groups. Due to the small sample size of COVID nursing homes, only bivariate analyses were conducted using odds ratios. CFRs were calculated by dividing the number of resident deaths by the number of cases at one facility. A medium CFR was derived from the literature. Mortality rates were calculated by dividing the number of resident deaths by the total number of residents at one facility. All reported P values were based on 2-sided testing. P values <0.05 were considered statistically significant. Subgroup analyses were conducted on MM1 nursing homes only in order to control for the rate of community spread of COVID-19.

2.9 | Ethics

As the study used public-domain administrative information and data not relating to individual humans, approval by an institutional research ethics committee was not required.

3 | RESULTS

3.1 | Overview

During the second wave, 9.7% (n = 74/766) of nursing homes had at least one resident as a confirmed case with COVID-19.

Facilities recording intrusion of COVID-19 (Table 1) were more often located in metropolitan regions (MM1 class), larger in size (accommodating more than 101 residents), part of a large chain, privately owned (n = 44, 59.5%) and more likely to be non-compliant with regulations (n = 19, 25.7%) and located in an area closer to a high-risk industry.

The relationship of acute hospital characteristics to facility outcomes could not be explored. This is due to the
### TABLE 1  Nursing homes by intrusion

| Variable                        | Intrusion | No intrusion | Total |
|---------------------------------|-----------|--------------|-------|
|                                 | N         | %            | N     | %    |
| Nursing homes                   |           |              |       |      |
| Total NHs                        | 74        | 9.7          | 692   | 90.3 |
| Resident population             | 7119      | 12.4         | 50512 | 87.6 |
| Residents                       | 488       | 64.1         | 252   | 32.9 |
| Number of residents*            |           |              |       |      |
| 1-50                            | 6         | 8.1          | 246   | 35.6 |
| 51-100                          | 38        | 51.4         | 280   | 40.5 |
| 101 and greater                 | 30        | 40.5         | 166   | 24.0 |
| Maximum room occupancy          |           |              |       |      |
| Single only                     | 44        | 59.5         | 444   | 64.6 |
| Double or more                  | 30        | 40.5         | 243   | 35.4 |
| Number of facilities*           |           |              |       |      |
| 1                               | 13        | 17.6         | 153   | 22.1 |
| 2-10                            | 22        | 29.7         | 287   | 41.5 |
| 11 or more                      | 39        | 52.7         | 252   | 36.4 |
| Ownership*                      |           |              |       |      |
| Private                         | 44        | 59.5         | 283   | 42.7 |
| Not-for-profit                  | 29        | 39.2         | 251   | 36.3 |
| Public                          | 1         | 1.4          | 158   | 22.8 |
| Board of governance             | 62        | 83.8         | 614   | 89.4 |
| Yes                             | 23        | 31.1         | 268   | 39.0 |
| CEO Clinical                    | 19        | 25.7         | 105   | 15.3 |
| Compliance*                     |           |              |       |      |
| Non-compliant                   | 39        | 52.7         | 124   | 16.3 |
| MMM remoteness*                 |           |              |       |      |
| 1                               | 69        | 93.2         | 404   | 58.4 |
| 2-4                             | 4         | 5.4          | 161   | 23.3 |
| 5-7                             | 1         | 1.4          | 127   | 18.4 |
| SES category                    |           |              |       |      |
| 1-3                             | 13        | 17.6         | 175   | 25.3 |
| 4-6                             | 19        | 25.7         | 214   | 30.9 |
| 7-10                            | 42        | 56.8         | 303   | 43.8 |
| Proximity to high risk industry*|           |              |       |      |
| Within 10 km                    | 29        | 39.2         | 203   | 29.5 |
| 10-25 km                        | 36        | 48.7         | 273   | 39.6 |
| >25 km                          | 9         | 12.2         | 213   | 30.9 |
| Proximity to a public hospital* |           |              |       |      |
| Within 10 km                    | 59        | 79.7         | 435   | 63.1 |
| 10-25 km                        | 11        | 14.9         | 86    | 12.5 |
| >25 km                          | 4         | 5.4          | 168   | 24.4 |
| Size of closest hospital*       |           |              |       |      |
| 1-100                           | 9         | 12.2         | 130   | 18.8 |
| 10-500                           | 28        | 37.8         | 348   | 50.4 |
| >500                             | 37        | 50.0         | 213   | 30.8 |

*P < 0.05.
second wave being contained to metropolitan Melbourne where most aged care facilities are in close proximity to a large hospital.

Subgroup analysis (Tables S1 and S2) comparing only nursing homes in MM1 regions did not generate any additional insights.

3.2 | Outbreak

Of those 74 (9.7%) nursing homes with an outbreak, two thirds (n = 50) were classified as having a large outbreak. A small outbreak was more likely in homes (Table 2) with single rooms for each resident (n = 17, 70.8%) and a board of governance (n = 22, 91.7%). A large outbreak was more likely in homes in metropolitan areas (n = 50, 100%), accommodating 91 or more residents (n = 27, 54%), with shared rooms (n = 23, 46%), and owned by private providers (n = 34, 68%) operating 11 or more facilities (n = 28, 56%).

3.3 | Mortality

The overall resident CFR in Victoria of 33.1% (648/1957) almost entirely comprised cases from metropolitan areas (646/1945).

At a facility level, over one third (n = 27, 36.5%) had a low CFR (below 26%), while thirty homes (40.5%) had a high CFR.

Higher resident CFR due to a COVID-19 outbreak was more likely in homes (Table 3) operated by not-for-profit providers, who accounted for half of the facilities with high mortality (n = 15/30, 50%) yet only comprise 40% (n = 29/74) of all nursing homes, which had outbreaks. Providers operating 11 or more facilities accounted for two-thirds of nursing homes with higher mortality rates (n = 20, 66.7%) and those located in close proximity to a high-risk industry accounted for half (n = 15, 50%).

Conversely, lower resident CFR was more likely in homes (Table 3) with single rooms for each resident.

Bivariate statistical analyses (Table S3) did not generate any additional insights and were limited by low event counts.

4 | DISCUSSION

4.1 | Key findings

Nursing homes where intrusion occurred were large metropolitan-based homes, with private ownership and previous non-compliance with the ACQSC. Homes with larger outbreaks had shared accommodation and were owned by a large chain operator. The factors more common in facilities with high CFRs had a not-for-profit provider and close proximity to a high-risk industry.

4.2 | Strengths and limitations

This research has the inherent limitations of an observational study using administrative or secondary data sources, including possible incompleteness of data. The use of published official government statistics provides a degree of mitigation concerning reliability and validity.

Ascertainment of nursing homes with a COVID-19 intrusion is based on screening and identification of symptomatic cases. It is possible some nursing homes may have had intrusion that was not identified. Mass screening of all residents in all nursing homes would be required to determine that no cases of COVID-19 were missed, a logistically challenging task.

Ascertainment of the size of the outbreak was possible as all nursing homes with residents diagnosed with COVID-19 conducted screening of all residents. Factors important in containing the size of an outbreak include the early recognition of potential COVID-19 infection, prompt laboratory testing and a rapid initial response to contain transmission. Information about these aspects was not publicly available.

Ascertainment of the relationship of COVID-19 to mortality is complex. Resident deaths could have been directly and only due to COVID-19, partially due to COVID-19 or causally unrelated. Information about resident age, sex and co-morbidities, which are important characteristics related to mortality, was not available.

The timing and extent of any therapeutic interventions may also have influenced the mortality rate. Early recognition, and early treatment of residents with COVID-19, is associated with a lower rate of mortality. The range and approach of therapeutic interventions varied from the use of acute care substitution programs (e.g., hospital in the home), transfer of a small number of residents, through to partial and full evacuation of the nursing home.

Comparisons adjusting for demographic and clinical status of resident populations were not possible as individual resident data were not available.

Information about the performance of the public health outbreak management units for each nursing home was not available. Variation in response times and allocation of resources to individual nursing homes would influence the size of the outbreak and mortality. Anecdotal evidence suggested ability to conduct laboratory screening tests and turn-around time for test results varied during the second wave.

Information about the performance of the health system serving the nursing home’s catchment was not available. Variation in health-care expertise, resource and policy would
We include all nursing homes in Victoria with one resident positive COVID-19, comparing outbreak size (at least one resident with COVID) small outbreak vs large outbreak according to the selected variables.

*P < 0.05.

| Variable                      | Small outbreak (≤10 cases per 100 residents) | Large outbreak (>10 cases per 100 residents) | Total |
|-------------------------------|---------------------------------------------|---------------------------------------------|-------|
| Nursing homes                 |                                             |                                             |       |
| Total NHs                     | 24 32.4                                     | 50 67.6                                     | 74 100|
| Resident population           |                                             |                                             |       |
| Residents                     | 2118 29.8                                   | 5001 70.2                                   | 7119 100|
| Number of residents           |                                             |                                             |       |
| 1-90                          | 12 50.0                                     | 23 46.0                                     | 35 47.3|
| 91 and greater                | 12 50.0                                     | 27 54.0                                     | 39 52.7|
| Maximum room occupancy        |                                             |                                             |       |
| Single only                   | 17 70.8                                     | 27 54.0                                     | 44 59.5|
| Double or more                | 7 29.2                                      | 23 46.0                                     | 30 40.5|
| Number of facilities          |                                             |                                             |       |
| 1-10                          | 13 54.2                                     | 22 44.0                                     | 35 47.3|
| 11 or more                    | 11 45.8                                     | 28 56.0                                     | 39 52.7|
| Ownership*                    |                                             |                                             |       |
| Private                       | 10 41.7                                     | 34 68.0                                     | 44 59.5|
| Not-for-profit                | 13 54.2                                     | 16 32.0                                     | 29 39.2|
| Public                        | 1 4.2                                       | 0 0                                         | 1 1.4 |
| Board of governance           |                                             |                                             |       |
| Yes                           | 22 91.7                                     | 40 80.0                                     | 62 83.8|
| CEO Clinical                  |                                             |                                             |       |
| Yes                           | 9 37.5                                      | 14 28.0                                     | 23 31.1|
| Compliance                    |                                             |                                             |       |
| Non-compliant                 | 8 33.3                                      | 11 22.0                                     | 19 25.7|
| MMM Remoteness*              |                                             |                                             |       |
| 1                             | 19 79.2                                     | 50 100                                      | 69 93.2|
| 2-7                           | 5 20.8                                      | 0 0                                         | 5 6.8 |
| SES Category                  |                                             |                                             |       |
| 1-3                           | 5 20.8                                      | 8 16.0                                      | 13 17.6|
| 4-6                           | 3 12.5                                      | 16 32.0                                     | 19 25.7|
| 7-10                          | 16 66.7                                     | 26 52.0                                     | 42 56.8|
| Proximity to high risk industry |                                             |                                             |       |
| Within 10 km                  | 7 29.2                                      | 22 44.0                                     | 29 39.2|
| >10 km                        | 17 70.8                                     | 28 56.0                                     | 45 60.8|
| Proximity to a public hospital |                                             |                                             |       |
| Within 10 km                  | 20 83.3                                     | 39 78.0                                     | 59 79.7|
| >10 km                        | 4 16.7                                      | 11 22.0                                     | 15 20.3|
| Size of closest hospital      |                                             |                                             |       |
| 1-500                         | 11 45.8                                     | 26 52.0                                     | 37 50.0|
| >500                          | 13 54.2                                     | 24 48.0                                     | 37 50.0|

**TABLE 2** Nursing homes by size of outbreak
influence resident mortality. The geriatric and acute medicine support to the nursing homes in Melbourne were drawn from several hospitals, two of which carried the greatest volume of cases.

| TABLE 3 | Nursing homes by case-fatality rates (CFR) |
|----------|-----------------------------------------|
| Variable | Low CFR (<26%) | Medium CFR (26%-35%) | High CFR (>35%) | Total |
|          | N (% )        | N (%)        | N (%)        | N (%) |
| Nursing homes |                           |                           |                           |        |
| Total NHs   | 27 36.5 | 17 23.0 | 30 40.5 | 74 100 |
| Resident population |                           |                           |                           |        |
| Residents   | 2589 36.4 | 1636 23.0 | 2894 40.7 | 7119 100 |
| Number of residents |                       |                           |                           |        |
| 1-90        | 13 48.1 | 8 47.1 | 14 46.7 | 35 47.3 |
| 91 and greater | 14 51.9 | 9 52.9 | 16 53.3 | 39 52.7 |
| Maximum room occupancy |                           |                           |                           |        |
| Single only | 18 66.7 | 9 52.9 | 17 56.7 | 44 59.5 |
| Double or more | 9 33.3 | 8 47.1 | 13 43.3 | 30 40.5 |
| Number of facilities |                       |                           |                           |        |
| 1-10        | 14 51.9 | 11 64.7 | 10 33.3 | 35 47.3 |
| 11 or more  | 13 48.2 | 6 35.3 | 20 66.7 | 39 52.7 |
| Ownership |                           |                           |                           |        |
| Private     | 16 59.3 | 13 76.5 | 15 50.0 | 44 59.5 |
| Not-for-profit | 10 37.0 | 4 23.5 | 15 50.0 | 29 39.2 |
| Public      | 1 3.7 | 0 0 | 0 0 | 1 1.4 |
| Board of governance |                       |                           |                           |        |
| Yes         | 23 85.3 | 12 70.6 | 27 90.0 | 62 83.8 |
| CEO Clinical |                           |                           |                           |        |
| Yes         | 9 33.3 | 5 29.4 | 9 30.0 | 23 31.1 |
| Compliance |                           |                           |                           |        |
| Non-compliant | 6 22.2 | 4 23.5 | 9 30.0 | 19 25.7 |
| MMM Remoteness |                       |                           |                           |        |
| 1           | 23 85.2 | 16 94.1 | 30 100 | 69 93.2 |
| 2-7         | 4 14.8 | 1 5.9 | 0 0 | 5 6.8 |
| SES Category |                           |                           |                           |        |
| 1-3         | 6 22.2 | 3 17.7 | 4 13.3 | 13 17.6 |
| 4-6         | 4 14.8 | 6 35.3 | 9 30.0 | 19 25.7 |
| 7-10        | 17 63.0 | 8 47.1 | 17 56.7 | 42 56.8 |
| Proximity to high risk industry |                         |                           |                           |        |
| Within 10 km | 9 33.3 | 5 29.4 | 15 50.0 | 29 39.2 |
| >10 km      | 18 66.7 | 12 70.6 | 15 50.0 | 45 60.8 |
| Proximity to a public hospital |                         |                           |                           |        |
| Within 10 km | 20 74.1 | 15 88.2 | 24 80.0 | 59 79.7 |
| >10 km      | 7 25.9 | 2 11.8 | 6 20.0 | 15 20.3 |
| Size of closest hospital |                       |                           |                           |        |
| 1-500       | 11 40.7 | 9 52.9 | 17 56.7 | 37 50.0 |
| >500        | 16 59.3 | 8 47.1 | 13 43.3 | 37 50.0 |

4.3 Interpretation

To our knowledge, this is the first study examining the impact of the second wave of the COVID-19 pandemic on nursing
homes in Victoria. It is also among a growing number internationally to examine whether a broad range of structural and facility characteristics are associated with intrusion, outbreak size and mortality.\textsuperscript{26,27}

Information from this study contributes to the international scientific literature, which is seeking to better understand why residents in nursing homes account for such a disproportionate number of deaths. Individual resident characteristics are not the full explanation, as community-dwelling older persons have not been affected to anywhere near the same extent.\textsuperscript{3} In Victoria, the number of deaths of older persons outside of nursing homes was very small.\textsuperscript{15,28}

Other studies have focused on the usual domains for investigating and reporting infectious outbreaks such as genomic, community outbreak characteristics and infection control strategies.\textsuperscript{7,29}

Other studies with similar conceptual designs to ours have demonstrated associations between mortality and quality ratings,\textsuperscript{10} and with the number of shared rooms.\textsuperscript{11}

Studies with a different design and population have examined nursing home facilities from the perspective of factors such as building design, ventilation, ownership and governance.\textsuperscript{9,12,13}

This study complements and expands upon this existing literature and suggests the potential importance of actions beyond the ordinary scope of practice of nursing homes in preventing adverse outcomes to residents.

4.4 Generalisability

The findings are plausible from a sociological, human services management and quality of care systems approach. Generalisation to other settings and countries, however, should be approached with caution, as there are variations between each country prepandemic in their structure and operations of aged and health-care systems. There are also variations in their pandemic public health response to the broad community and specifically to nursing homes.

Prepandemic, Australia’s health system was recognised as world class. However, the aged care system was being investigated by a Royal Commission due to issues with poor performance, neglect and abuse due to being under resourced and ill-equipped.\textsuperscript{5}

The role of ACQSC as a regulator (https://www.agedcarequality.gov.au/about-us), the setting of standards, and the nature and reliability of accreditation surveys have also been contentious matters under close scrutiny in Australia.\textsuperscript{30}

When the pandemic arrived, Australia had significant advantages in managing and containing the pandemic, being an island continent with a very low population density and excellent community adherence to public health measures. During the second wave, Melbourne was in a lockdown for 111 days commencing in July 2020, which comprised enforcing home confinement, strict travel restrictions, closing retail stores and restaurants, and restricted access to aged care facilities. This was a major factor in controlling the pandemic second wave in Victoria.

4.5 Key implications

This study demonstrates an innovative approach to better understanding the potential contribution of underlying structural and organisational factors to the health outcomes of nursing home residents.

Further research is required to identify factors associated with risk of intrusion apart from the level of community transmission in which the nursing home is located. In particular, attention is required to identify those factors, which are modifiable and within the locus of control of the facility, and whether and how differing levels of community transmission impact on nursing homes at an individual and jurisdictional level. Nursing homes are at a disproportionately high risk of intrusion, even with very low levels of community transmission.

Further insights are required in understanding whether the greater levels of morbidity and mortality evident in nursing home residents are due to inherent individual biological and disease factors, or whether the staff, facility and the nature of the emergency management response contribute. This could be elucidated by comparing community-dwelling older persons with similar co-morbidities and functional impairments to residents of nursing homes. In Australia, such a group could be those on a home care package level 4.

Early, pertinent and more detailed information about the characteristics of individual nursing homes would allow for a better public health response. A minimum data set could be developed describing the core elements of governance, workforce, models of care, capability with self-evaluation and data interpretation, availability of internal and external resources, and resident population characteristics.

It should also be considered that excess deaths, not recorded in our present methodology, may also occur due to consequential neglect of residents who do not have COVID-19, as the allocation of resources to address an outbreak creates deficits in care elsewhere.

5 CONCLUSIONS

This study provides information that is useful for stratification of nursing homes according to characteristics associated with a greater likelihood of morbidity and mortality. This is an approach commonly used in risk management and
prioritises nursing homes for intervention where the most benefits could be made.

This study also informs policy for approaching a jurisdictional-level vaccination campaign. Mass vaccination requires time, and therefore the sequence in distribution will require decisions about how to prioritise the most vulnerable residents, in the most vulnerable nursing homes, in the most vulnerable communities.

Finally, the architectural design, built environment and operations of nursing homes must adapt in the short and long term to address optimal approaches to prevent harm from future waves and other pandemics.

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CONFLICTS OF INTEREST
The authors are affiliated with or employed by the Department of Forensic Medicine, Monash University, which is also a funding source. The authors have no other potential financial or personal interests that may constitute a source of bias.

DATA AVAILABILITY STATEMENT
The data that supports the findings of this study are derived from public domain resources described in the supplementary material of this article.

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**SUPPORTING INFORMATION**

Additional supporting information may be found online in the Supporting Information section.

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