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Risk Stratification of Nursing Homes to Plan COVID-19 Responses: A Case Study of Victoria, Australia

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Original Research

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Abstract

Objective: Emergency management responses to coronavirus disease 2019 (COVID-19) in nursing homes lacked preparation and nuance; moving forward, responses must recognize nursing homes are not generic organizations or services, and individually appreciate each's unique nature, strengths, and limitations. The objective of this study was to describe an approach to stratifying nursing homes according to risk for COVID-19 outbreak.

Methods: Population-based cross-sectional study of all accredited nursing homes in Victoria ($n = 766$), accommodating 48,824 permanent residents. We examined each home's facility structure, governance history, socio-economic status, proximity to high-risk industry, and proximity and size of local acute public hospital, stratified by location, size, and organizational structure.

Results: Privately owned nursing homes tend to be larger and metropolitan-based, and publicly owned homes regionally based and smaller in size. The details reveal additional nuance, eg, privately owned metropolitan-based medium- to large-sized facilities tended to have more regulatory noncompliance, no board of governance, and fewer Chief Executive Officers with clinical background. In contrast, the smaller, publicly owned, remote facilities perform better on those same metrics.

Conclusions: Nursing homes should not be regarded as generic entities, and there is significant underlying heterogeneity. Stratification of nursing homes according to risk level is a viable approach to informing more nuanced policy direction and resource allocation for emergency management responses.

The coronavirus disease 2019 (COVID-19) pandemic has had devastating effects on nursing home residents around the world,[1–3] demanding considered decision-making to guide optimal emergency management responses.[4] However, internationally in countries including Australia,[5] North America,[6] and the United Kingdom,[7] responses to the pandemic, particularly in nursing homes, lacked preparation, and prevention and mitigation strategies lacked nuance. Nursing homes were treated as generic services, rather than as disparate individual organizations, with limited understanding of each's unique nature, strengths, and limitations.[2,5] This is despite the availability of evidence suggesting that individual nursing home factors can be associated with significant differences in quality of care outcomes[8–11]

To guide the development of more nuanced strategies to address COVID-19 in this setting, we propose 4 domains specific to nursing homes, to complement general public health strategies. These domains are: (1) preventing viral introduction into the nursing home; (2) containing the outbreak within the nursing home quickly; (3) maintaining usual operations, ensuring adequate care to residents not infected; and (4) accessing acute health care for those unwell from COVID-19 or other conditions.

A nursing home's ability to address these domains is impacted differently by:

The location of nursing homes: Geographic remoteness is linked to the availability of resources; in particular, health-care access and capacity.[12] Remoteness is also a proxy for population density, which relates to the likelihood of a local COVID-19 outbreak and viral introduction into the nursing home.[13,14] Similarly, a nursing home's specific location relative to high-risk industries (such as meatworks[15]) also affects the risk of viral introduction.

Organizational structure and capability: Governance and leadership play critical roles in an organization facing an emergency, and reflect in part the owners' mission, organizational structure, and culture. Each major nursing home ownership type—private, not-for-profit, and public sector—has differing models of care, workforce arrangements and daily operations, which impact on quality of care.[2,8–10,16]

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The size of their vulnerable population: Protecting the greatest number of residents serves the utilitarian principle of achieving the most good for the most people.[17,18] This requires identifying those who have the greatest potential risk of harm,[11] and prioritizing those where an effective intervention is implementable.

Emergency management commanders must undertake decision-making processes that involve considering and weighing multiple possible scenarios. This study explores scenarios whereby nursing homes are stratified according to the preceding 3 factors to ascertain if there are any insights that may improve responses.

Aim

To describe 3 different approaches to risk stratification of nursing homes in planning emergency management responses to the COVID-19 pandemic.

Methods

Study Design

The study comprised a population-based cross-sectional study of all nursing homes in Victoria, which is Australia's second most populous jurisdiction, and in 2020 had a population of 6.7 million people, of which 1,054,741 (15.8%) were aged 65 or older.[19]

The study included all nursing homes in Victoria accredited by the Australian Aged Care Quality and Safety Commission (ACQSC) as of June 2020. This comprised 766 operational residential aged care services, accommodating 48,824 permanent residents.[20]

All data were obtained from the following publicly available sources:

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 per facility[21,22]

Australian Aged Care Quality and Safety Commission data on any noncompliance or sanctions imposed on the nursing home by the regulator[23]

Australian Bureau of Statistics and Department of Health data describing the socio-economic status (SES) of nursing homes according to postcode and geographic remoteness,[24,25] according to the Modified Monash Model (MMM) geographical classification system[26]

"Farm Transparency Project" data used to identify the location of abattoirs[27]

Each nursing home's website, accessed by Google search, to identify the incumbent chief executive officer (CEO) and whether the nursing home had a board of governance

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

The variables for analyses were extracted only from data reported before July 2020. The research staff gathered this information during August and October 2020.

Variables

Nursing homes were stratified according to location (by MMM classification of geographic remoteness), size of facility (number of beds), and type of ownership (private for-profit, private not-for-profit, or public-sector).

Nine variables pertaining to a nursing home's emergency management response to a COVID-19 outbreak were considered. Seven were nursing home characteristics: (V-1) the number of separate facilities the provider operated, (V-2) whether a board of governance was in place, (V-3) whether the CEO had a clinical qualification, (V-4) proportion of 1-bed, or multiple bedrooms, (V-5) a history of regulatory noncompliance, (V-6) socio-economic status, and (V-7) proximity to high-risk industry. Two were acute hospital characteristics: (V-8) proximity to an acute public hospital, and (V-9) the size of that hospital.

Data Sources and Measurement

Each variable of interest, sources of data, and grouping or categories used in the analysis are described in Supplementary Table S1. Categories were generated based on clinical criteria. Some were combined into groupings of 3 to allow for easier comparison.

Chi-squared analyses were conducted on the categorical variables. Post-hoc Bonferroni-adjusted *P*-values were also calculated: $P < 0.05$ was considered to be significant. All analyses were conducted using Stata 16 (College Station, TX: StataCorp LLC).

Ethics

As the study used public-domain information and data not relating to humans, the study is exempt from review by the Monash University Human Research Ethics Committee.

Results

Scenario 1: Location

Stratifying nursing homes according to remoteness (Table 1) highlights that the majority of residents (71.4%) dwell in the 61.8% of homes located in metropolitan regions. The proportion of nursing homes with a record of past regulatory noncompliance was similar in metropolitan and regional centers (18.3% and 18.2%, respectively) and lowest in rural/remote areas (6.3%; $\chi^2(2) = 11.2$; $P = 0.004$).

The nursing homes with relatively greater proximity to a high-risk industry were in regional areas (43.6%) in contrast to those in rural/remote areas (10.9%; $\chi^2(4) = 238.6$; $P < 0.001$). The geographic regions with the most relative socio-economic disadvantage were regional and rural/remote (48.5% and 44.5%, respectively). In contrast, two-thirds of metropolitan nursing homes (67.9%) were located in the wealthiest socio-economic areas ($\chi^2(4) = 272.6$; $P < 0.001$).

The nursing homes with structural advantages to contain an outbreak were located in rural/remote areas, with facilities with smaller sized nursing homes (1-50 residents: 83.6%) with no shared rooms (62.2%). Somewhat surprising was that distribution of single rooms in nursing homes was similar and just under two-thirds across all geographic locations ($\chi^2(2) = 0.32$; $P = 0.9$).

The most common ownership type of nursing homes varied dramatically according to location (Table 1). Privately owned homes (57.1%) were mostly metropolitan, public sector homes (67.2%) in rural/remote areas, and not-for-profits (40%) in regional areas ($\chi^2(4) = 275.7$; $P < 0.001$). Although the majority of homes had a board of governance in all geographic areas, the proportion of nursing homes with a CEO who had clinical qualifications increased with remoteness ($\chi^2(2) = 6.9$; $P = 0.03$).

As expected, proximity to an acute public hospital decreased with increasing remoteness. Most metropolitan nursing homes (83.8%) were within 10 km of an acute hospital, while most

Table 1. Comparison of nursing homes according to location as defined by MMM category of remoteness

		Metropolitan (MM 1)		Regional centers/ medium rural towns (MM 2-4)		Small rural towns/ remote (MM 5-7)		Total	
Variable	Sub-group	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)
Nursing homes									
	Total nursing homes	473	61.8	165	21.5	128	16.7	766	100
Resident population									
	Residents	41174	71.4	12388	21.5	4069	7.1	57631	100
No. of residents*									
	1-50	96	20.3*	49	29.7	107	83.6*	252	32.9
	51-100	220	46.5*	79	47.9	19	14.8*	318	41.5
	101 and greater	157	33.2*	37	22.4	2	1.6*	196	25.6
Maximum room occupancy									
	Single only	304	64.8	105	63.6	79	62.2	488	64.1
	Double or more	165	35.2	60	36.4	48	37.8	273	35.9
No. of facilities*									
166 groups	1	90	19.0*	44	26.7	32	25.0	166	21.7
80 groups	2-10	157	33.2*	63	38.2	89	69.5*	309	40.3
16 groups	11 or more	226	47.8*	58	35.2	7	5.5*	291	38.0
Ownership*									
	Private	270	57.1*	47	28.5*	10	7.8*	327	42.7
	Not-for-profit	182	38.5	66	40.0	32	25.0*	280	36.6
	Public	21	4.4*	52	31.5*	86	67.2*	159	20.8
Board of governance*									
	Yes	401	85.5*	154	93.3*	121	95.3*	676	88.8
CEO clinical*									
	Yes	163	34.8*	69	41.8	59	46.5*	291	38.2
Compliance*									
	Non-compliant	86	18.3	30	18.2	8	6.3*	124	16.3
SES category*									
	1-3	51	10.8*	80	48.5*	57	44.5*	188	24.5
	4-6	101	21.4*	72	43.6*	60	46.9*	233	30.4
	7-10	321	67.9*	13	7.9*	11	8.6*	345	45.0
Proximity to high-risk industry*									
	Within 10 km	146	31.1	72	43.6*	14	10.9*	232	30.4
	10-25 km	263	56.0*	28	17.0*	18	14.1*	309	40.5
	>25 km	61	13.0*	65	39.4*	96	75.0*	222	29.1
Proximity to a public hospital*									
	Within 10 km	394	83.8*	97	58.8	3	2.3*	494	64.5
	10-25km	71	15.1*	20	12.1	6	4.7*	97	12.7
	>25km	5	1.1*	48	29.1*	119	93.0*	172	22.5
Size of closest hospital*									
	1-100	44	9.3*	34	20.6	61	47.7*	139	18.2
	101-500	182	38.6*	128	77.6*	66	51.6	376	49.2
	>500	246	52.1*	3	1.8*	1	0.8*	250	32.7

*$P < 0.05$ (Bonferroni-adjusted P in post-hoc analysis).

rural/remote nursing homes were more than 25 km away (93%; $\chi^2(4) = 493.9$; $P < 0.001$). This same pattern was reflected in the size of the closest hospital, with most large hospitals being in metropolitan areas ($\chi^2(4) = 262.7$; $P < 0.001$).

Scenario 2: Organizational Structure and Capability

Stratifying according to ownership type (Table 2) highlights that the majority of residents (53%) dwell in the 42.7% of homes owned by private organizations. The ownership type with the worst record of past regulatory noncompliance was not-for-profit (21.2%; $\chi^2(2) = 11.4$; $P = 0.003$).

Privately owned homes were more often in closer proximity to a high-risk industry. Public-sector owned homes were located in areas of the most relative socio-economic disadvantage (44.7%; $\chi^2(4) = 91.4$; $P < 0.001$).

Public-sector-owned nursing homes had structural advantages to contain an outbreak because of smaller number of residents,

Table 2. Comparison of nursing homes according to ownership type

		Private		Not-for-profit		Public		Total	
Variable	Sub-group	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)
Nursing homes									
	Total nursing homes	327	42.7	280	36.6	159	20.8	766	100
Resident population									
	Residents	30530	53.0	21972	38.1	5129	8.9	57631	100
No. of residents*									
	1-50	39	11.9*	76	27.1*	137	86.2*	252	32.9
	51-100	168	51.4*	131	46.8*	19	12.0*	318	41.5
	>100	120	36.7*	73	26.1	3	1.9*	196	25.6
Maximum room occupancy*									
	Single only	184	56.6*	213	76.6*	91	57.6	488	64.1
	Double or more	141	43.4*	65	23.4*	67	42.4	273	35.9
No. of facilities*									
166 groups	1	51	15.6*	92	32.9*	23	14.5*	166	21.7
80 groups	2-10	93	28.4*	80	28.6*	136	85.5*	309	40.3
16 groups	11 or more	183	56.0*	108	38.6	0	0.0*	291	38.0
Board of governance*									
	Yes	260	80.0*	258	92.8*	158	100*	676	88.8
CEO clinical*									
	Yes	66	20.3*	126	45.3*	99	62.7*	291	38.2
Compliance*									
	Non-compliant	51	15.7	59	21.2*	14	8.9*	124	16.3
MMM remoteness*									
	1 (Metropolitan)	270	82.6*	182	65.0	21	13.2*	473	61.8
	2-4	47	14.4*	66	23.6	52	32.7*	165	21.5
	5-7	10	3.1*	32	11.4*	86	54.1*	128	16.7
SES category*									
	1-3	51	15.6*	66	23.6	71	44.7*	188	24.5
	4-6	88	26.9	79	28.2	66	41.5*	233	30.4
	7-10	188	57.5*	135	48.2	22	13.8*	345	45.0
Proximity to high risk industry*									
	Within 10 km	103	31.7	91	32.6	38	23.9*	232	30.4
	10-25 km	172	52.9*	116	41.6	21	13.2*	309	40.5
	>25 km	50	15.4*	72	25.8	100	62.9*	222	29.1
Proximity to a public hospital*									
	Within 10 km	242	74.5*	200	71.7*	52	32.7*	494	64.5
	10-25 km	58	17.9*	34	12.2	5	3.1*	97	12.7
	>25 km	25	7.7*	45	16.1*	102	64.2*	172	22.5
Size of closest hospital*									
	1-100	36	11.0*	45	16.1	58	36.5*	139	18.2
	101-500	155	47.6	132	47.1	89	46.0	376	49.2
	>500	135	41.4*	103	36.8	12	7.6*	250	32.7

*$P < 0.05$ (Bonferroni-adjusted P in post-hoc analysis).

with 137 facilities (86.2%) accommodating 50 or fewer residents ($\chi^2(4) = 277.4$; $P < 0.001$). Interestingly, not-for-profits had the most facilities providing accommodation with no shared rooms (76.6%; $\chi^2(2) = 29.8$; $P < 0.001$). Organizations that operated multiple (≥11) facilities were typically private providers; in contrast, approximately one-third of not-for-profit providers operated a single facility ($\chi^2(2) = 215.4$; $P < 0.001$).

As expected, all the public sector owned nursing homes had a board of governance ($n = 158$, $\chi^2(2) = 49.8$; $P < 0.001$), and the majority had a CEO with clinical qualifications (62.7%; $\chi^2(2) = 90.0$; $P < 0.001$).

Close proximity to an acute public hospital was far less frequent for nursing homes that were owned by the public sector (62.9%; $\chi^2(4) = 209.3$; $P < 0.001$).

Scenario 3: Size of Facility, Protecting the Greatest Number of Residents

Stratifying nursing homes according to number of residents (Table 3) highlights more residents ($n = 25756$; 44.7%) dwell in 196 of the larger homes (25.6%). The nursing homes with a record

Table 3. Comparison of nursing homes based on size (ie, number of residents accommodated)

		1-50 beds		51-100 beds		>100 beds		Total	
Variable	Sub-group	N	(%)	N	(%)	N	(%)	N	(%)
Nursing homes									
	Total nursing homes	252	32.9	318	41.5	196	25.6	766	100
Resident population									
	Residents	7981	13.8	23894	41.5	25756	44.7	57631	100
Maximum room occupancy									
	Single only	168	67.7	190	59.9	130	66.3	488	64.1
	Double or more	80	32.3	127	40.1	66	33.7	273	35.9
No. of facilities*									
	1	53	21.0	78	24.5	35	17.9	166	21.7
	2-10	155	61.5*	89	28.0*	65	33.2*	309	40.3
	11 or more	44	17.5*	151	47.5*	96	49.0*	291	38.0
Ownership*									
	Private	39	15.5*	168	52.8*	120	61.2*	327	42.7
	Not-for profit	76	30.2*	131	41.2*	73	37.2	280	36.6
	Public	137	54.4*	19	6.0*	3	1.5*	159	20.8
Board of governance									
	Yes	228	91.9	273	86.1	175	89.3	676	88.8
CEO clinical*									
	Yes	126	50.8*	98	30.9*	67	34.2	291	38.2
Compliance*									
	Non-compliant	29	11.7*	44	13.9	51	26.0*	124	16.3
MMM remoteness*									
	1 (Metropolitan)	96	38.1*	220	69.2*	157	80.1*	473	61.8
	2-4	49	19.4	79	24.8	37	18.9	165	21.5
	5-7	107	42.5*	19	6.0*	2	1.0*	128	16.7
SES category*									
	1-3	88	34.9*	73	23.0*	27	13.8*	188	24.5
	4-6	89	35.3*	85	26.7	59	30.1	233	30.4
	7-10	75	29.8*	160	50.3*	110	56.1*	345	45.0
Proximity to high risk industry*									
	Within 10 km	56	22.4*	116	36.6*	60	30.6	232	30.4
	10-25 km	70	28.0*	138	43.5	101	51.5*	309	40.5
	>25 km	124	49.6*	63	19.9*	35	17.9*	222	29.1
Proximity to a public hospital*									
	Within 10 km	111	44.4*	232	73.2*	151	77.0*	494	64.7
	10-25 km	16	6.4*	48	15.1	33	16.8*	97	12.7
	>25 km	123	49.2*	37	11.7*	12	6.1*	172	22.5
Size of closest hospital*									
	1-100	76	30.2*	43	13.6*	20	10.2*	139	18.2
	101-500	119	47.2	155	48.9	102	52.0	376	49.2
	>500	57	22.6*	119	37.5*	74	37.8	250	32.7

*$P < 0.05$ (Bonferroni-adjusted P in post-hoc analysis).

of past regulatory noncompliance were mostly larger in size (26%; $\chi^2(2) = 18.8$; $P < 0.001$) in both relative and absolute terms.

The nursing homes that accommodated the largest numbers of residents (>100 residents) were mostly in metropolitan areas (80.1%; $\chi^2(4) = 189.9$; $P < 0.001$) and the nursing homes with a close proximity to a high-risk industry were medium in size (36.6%; $\chi^2(4) = 79.4$; $P < 0.001$). The homes located in areas of the most relative socio-economic disadvantage were small in size (34.9%; $\chi^2(4) = 44.4$; $P < 0.001$).

The nursing homes with structural advantages to contain an outbreak because they were small in size were located in metropolitan and rural/remote areas (38.1% and 42.5%). There were no significant differences in the proportion of facilities that offered accommodation with no shared rooms (67.7% and 66.3%; $\chi^2(2) = 4.2$; $P = 0.1$).

The most common ownership type of nursing homes varied according to size (Table 4). Large and medium homes were typically privately owned, while not-for-profits operated relatively

Table 4. Comparison of nursing homes and resident frequencies according to nursing home size, ownership, and geographic location

	Private				Not for profit				Public				Total			
	Nursing homes		Residents		Nursing homes		Residents		Nursing homes		Residents		Nursing homes		Residents	
Size	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Metropolitan area																
Small	35	4.6	1491	2.6	47	6.1	1829	3.2	14	1.8	427	0.7	96	12.5	3747	6.5
Med	134	17.5	10145	17.6	80	10.4	5917	10.3	6	0.8	475	0.8	220	28.7	16537	28.7
Large	**101**	**13.2**	**13637**	**23.7**	55	7.2	7055	12.2	1	0.1	198	0.3	**157**	**20.5**	**20890**	**36.2**
Regional areas																
Small	3	0.4	137	0.2	7	9.1	296	0.5	39	5.1	1306	2.3	49	6.4	1739	3.0
Med	27	3.5	2137	3.7	**41**	**5.4**	**3206**	**5.6**	11	1.4	663	1.2	79	10.3	6006	10.4
Large	17	2.2	2148	3.7	18	2.3	2222	3.9	2	0.3	273	0.5	37	4.8	4643	8.1
Rural areas																
Small	1	0.1	25	0.04	22	2.9	795	1.4	**84**	**11.0**	**1675**	**2.9**	107	14.0	2495	4.2
Med	7	0.9	587	1.0	10	1.3	652	1.1	2	0.3	112	0.2	19	2.5	1351	2.3
Large	2	0.3	223	0.3	0	0	0	0	0	0	0	0	2	0.3	223	0.4
Total																
	327	42.7	30530	52.8	280	44.7	21972	38.2	159	20.8	5129	8.9	766	100	57631	100

Note: The bolded sections illustrate the largest subpopulation. Consider the row that is shaded and bolded—comprising one-third of residents (36.2%) dwelling in 157 nursing homes (20.5%), predominately owned by the private providers. This subgroup is the one that would be prioritized with additional resource allocation if a utilitarian approach is the guiding policy principle.

evenly across all-sized homes, and the public sector was dominant in small homes.

Presence of a board of governance was similar across the different-sized homes ($\chi^2(2) = 4.8$; $P = 0.09$); however, only in smaller homes did a majority of CEOs have clinical qualifications (50.8%; $\chi^2(2) = 25.2$; $P < 0.001$).

Close proximity to an acute public hospital was far less frequent for nursing homes that were small-to-medium in size ($\chi^2(4) = 79.4$; $P < 0.001$). Most of the small nursing homes (49.2%; $\chi^2(4) = 154.8$; $P < 0.001$) were more than 25 km away from an acute hospital.

Inter-relationship Between the 3 Scenarios

Examining the 3 scenarios collectively (Table 4) highlights that the strata are interrelated and not mutually exclusive. For example, the larger the facility size, the more likely it was to be metropolitan-based, and the more urban the location, the more likely it would be owned by a private provider. Conversely, the smaller the size of the facility, and the more rural the location, the more likely it was to be publicly owned. The not-for-profits often formed the middle part of the gradient.

Limitations and Strengths

The limitations of this study are those inherent to the use of secondary administrative data sources. Issues with data collection and accuracy have been minimized by using official government sources wherever possible. However, use of administrative data limits what variables could be examined, often being restricted to broad structural indicators rather than specific process measures. For example, it would be preferable to evaluate CEO performance in clinical areas rather than rely on whether the person had a qualification.

Potential biases could lead to either an under- or over-estimate of estimated proportions. However, this does not detract from the principles being explored or from the resulting observations in the setting of this hypothesis-generating study.

The strengths of this study lie in the use of the whole population of a large jurisdiction, the novel approach of risk stratification of nursing homes according to 3 factors, and the exploration of how these may impact on different aspects of pandemic response management.

Discussion

Key Findings

This hypothesis-generating study examined 3 different scenarios for stratification of Victorian nursing homes according to location, size, and ownership. The stratification highlights commonalities between the factors, such that privately owned nursing homes tended to be larger and metropolitan-based, while publicly owned homes tended to be regionally based and smaller in size. However, there is more nuance in the details; for example, privately owned metropolitan-based medium-to-large-sized facilities tended to have more regulatory noncompliance, no board of governance, and fewer CEOs with clinical background. In contrast, the smaller, publicly owned, remote facilities performed better on those same metrics.

Practical Implications

This study demonstrates that profiling the nursing homes in a jurisdiction could inform more nuanced policy direction and resource allocation. The expectation that nursing homes should prepare and develop their own emergency response plans to the pandemic as if they operate completely independently is flawed.

In Australia, communicable disease guidelines explicitly state that providers are responsible for an emergency management response to the COVID-19 pandemic.[28] However, this study highlights significant differences when nursing homes are profiled across different domains. More concerningly, these 3 groupings are considerably heterogeneous and in fact represent 262 different individual providers, permitting huge variations in approaches.

In a practical context, the approach described in this study lends itself to developing emergency management responses that are better guided by jurisdictional priorities. The approach advanced by our study adds sophistication to the current blunt and simplistic approach of considering each nursing home as being a generic organization, while also accommodating regional variations in risk and transmission. Developing such risk-stratification approaches, or at the very least, examining the finer details and differences in nursing home characteristics, may enable more nuanced pandemic responses.

For example, if priorities are informed by geographic remoteness, then more resources are needed to support the smaller homes in rural/remote areas, whose local acute-care hospitals are smaller and more distant. Under such circumstances, a regional command center might be better placed than individual nursing home providers to co-ordinate with the hospital.

If prioritizing larger-sized nursing homes, this addresses the greatest vulnerable population; however, the co-ordination of response may be more difficult. The results of the study suggest that the wide range of aged care providers, geographic distribution, and disparate conditions within each home may create challenges in tailoring an approach that would be beneficial to the majority.

If prioritizing responses according to nursing homes under different ownership models, this potentially addresses the most vulnerable nursing homes. However, large operators who have substantial existing infrastructure and experience are quite different to solo operators.

Similarly, it is expected that responses to any future waves of COVID-19 or other pandemics or disasters can be made better tailored, more effective, efficient, and economically viable by matching the allocation of resources to address the specific risks a nursing home confronts.

For example, reducing the risk of viral introduction requires greater investment in the nursing homes located in metropolitan areas, with relatively lower socio-economic disadvantage, and in close proximity to a high-risk industry, ie, stratification by location. Containing an outbreak requires greater investment in the nursing homes that have shared accommodation arrangements, a large number of residents, and are solo operators without workforce reserves from other facilities. Supporting an organization to maintain usual operations requires greater investment in nursing homes with prior history of regulatory noncompliance or that lack governance structures. Finally, nursing homes that are geographically remote have the most limited access to acute health-care resources.

Research Context and Future Directions

This study provides preliminary evidence in the growing body of research and commentary examining potential and actual approaches to managing the COVID-19 pandemic in nursing homes. It explores the different approaches using readily available public-domain data, enabling rapid analysis to facilitate planning—an area where there is a paucity of research. Of the few previously published studies, the aims have tended to focus on investigating risk factors for morbidity and mortality for individual residents or nursing homes, rather than on exploring jurisdiction-level approaches to emergency responses and risk stratification.[29–31]

The study methodology is readily transferable to other regions and countries. While available data sources may vary, and country-specific differences in aged care, health-care systems, geography, and population density need to be accommodated, there is face validity to the notion that the size, location, and ownership of a nursing home relate to resident outcomes during a pandemic. Empirical evidence supporting a relationship exists for other quality of care outcomes.[8–11]

This study begins to bridge the gap between theory and practice in emergency management responses to pandemic. The 3 scenarios presented are simplified examples designed to enlighten debate and promote a nuanced response to the pandemic, accounting for the strengths and limitations of individual provider organizations.

More research is required at 3 levels. First, gathering and evaluating public health policies and strategies for COVID-19 pandemic and nursing homes. Second, development and testing of stratification tools and models to promote efficient and effective resource allocation. Third, empirical studies to identify the important characteristics within the 4 domains (introduction, outbreak, organizational continuity, and access to health care) at individual, organizational, and jurisdictional levels that impact on overall morbidity and mortality.

For example, as the majority of residents in Victoria live in medium-to-large private metropolitan-based nursing homes, perhaps this is where initial emergency response efforts should be directed to reduce viral introduction and outbreaks. In contrast, the nursing homes in remote locations house smaller numbers of residents; however, these are at greater socio-economic disadvantage with limited access to acute hospitals, and as such, require different assistance should they be subject to a COVID-19 outbreak.

Accordingly, the results of this hypothesis-generating study raise at least 4 hypotheses in these areas to be tested in the future:

1. The geographic location, size, and ownership of a nursing home impact its internal level of preparedness to prevent, contain and manage infectious outbreak.
2. The geographic location, size, and ownership of a nursing home impact the rate of hospitalization and mortality of residents in an infectious outbreak.
3. The geographic location, size, and ownership of a nursing home influence the level of external support or resources needed during an infectious outbreak.
4. Preferential allocation of external resources based on either geographic location, size, or ownership of a nursing home impacts on the rate of resident hospitalization and mortality in an infectious outbreak.

Conclusions

An effective response to managing an emergency requires understanding principles of stratification according to the likelihood and consequences of specific scenarios, to tailor appropriate interventions. Protecting residents in nursing homes requires both community-wide public health interventions as well as specific plans tailored to individual homes' ability to prevent and respond to COVID-19 outbreaks.

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References

1. **Aitken GE, Holmes AL, Ibrahim JE.** COVID-19 and residential aged care: priorities for optimising preparation and management of outbreaks. *Med J Aust.* 2021;214(1):6-8.e1. doi: doi.org/10.5694/mja2.50892
2. **Cousins S.** Experts criticise Australia's aged care failings over COVID-19. *Lancet.* 2020;396(10259):1322-1323. doi: 10.1016/S0140-6736(20)32206-6
3. **Comas-Herrera A, Zalakaín J, Lemmon E, *et al.*** Mortality associated with COVID-19 in care homes: international evidence. LTCcovid.org. https://ltccovid.org/wp-content/uploads/2020/10/Mortality-associated-with-COVID-among-people-living-in-care-homes-14-October-2020-3.pdf. Accessed March 1, 2021.
4. **Hershkovich O, Gilad D, Zimlichman E, *et al.*** Effective medical leadership in times of emergency: a perspective. *Disaster Mil Med.* 2016;2(1):1-5. doi: 10.1186/s40696-016-0013-8
5. **Royal Commission into Aged Care Quality and Safety (AU).** Aged care and COVID-19: a special report. Adelaide: Royal Commission into Aged Care Quality and Safety (AU); 2020. https://agedcare.royalcommission.gov.au/publications/aged-care-and-covid-19-special-report. Accessed February 23, 2021.
6. **Ouslander JG, Grabowski DC.** COVID-19 in nursing homes: calming the perfect storm. *J Am Geriatr Soc.* 2020;68(10):2153-2162. doi: 10.1111/jgs.16784
7. **Amnesty International.** As if expendable: the UK Government's failure to protect older people in care homes during the COVID-19 pandemic. London: c2020. https://www.amnesty.org/download/Documents/EUR4531522020ENGLISH.PDF. Accessed February 28, 2021.
8. **Hillmer MP, Wodchis WP, Gill SS, *et al.*** Nursing home profit status and quality of care: is there any evidence of an association? *Med Care Res Rev.* 2005;62(2):139-166. doi: 10.1177/1077558704273769
9. **Comondore VR, Devereaux PJ, Zhou Q, *et al.*** Quality of care in for-profit and not-for-profit nursing homes: systematic review and meta-analysis. *BMJ.* 2009;339:b2732. doi: 10.1136/bmj.b2732
10. **Baldwin R, Chenoweth L, dela Rama M, *et al.*** Quality failures in residential aged care in Australia: the relationship between structural factors and regulation imposed sanctions. *Australas J Ageing.* 2015;34(4):E7-E12. doi: 10.1111/ajag.12165
11. **Baldwin R, Chenoweth L, dela Rama M, *et al.*** Does size matter in aged care facilities? a literature review of the relationship between the number of facility beds and quality. *Health Care Manage Rev.* 2017;42(4):315-327. doi: 10.1097/HMR.0000000000000116
12. **McGrail MR, Humphreys JS.** Spatial access disparities to primary health care in rural and remote Australia. *Geospat Health.* 2015;10(2):358. doi: 10.4081/gh.2015.358
13. **Bhadra A, Mukherjee A, Sarkar K.** Impact of population density on Covid-19 infected and mortality rate in India. *Model Earth Syst Environ.* 2021;7(1):623-629. doi: 10.1007/s40808-020-00984-7
14. **Pequeno P, Mendel B, Rosa C, *et al.*** Air transportation, population density and temperature predict the spread of COVID-19 in Brazil. *PeerJ.* 2020;8:e9322. doi: 10.7717/peerj.9322
15. **Middleton J, Reintjes R, Lopes H.** Meat plants—a new front line in the covid-19 pandemic. *BMJ.* 2020;370:m2716. doi: 10.1136/bmj.m2716
16. **Stall NM, Jones A, Brown KA, *et al.*** For-profit long-term care homes and the risk of COVID-19 outbreaks and resident deaths. *CMAJ.* 2020;192(33):E946-E955. doi: 10.1503/cmaj.201197
17. **Emanuel EJ, Persad G, Upshur R, *et al.*** Fair allocation of scarce medical resources in the time of Covid-19. *N Engl J Med.* 2020;382(21):2049-2055. doi: 10.1056/NEJMsb2005114
18. **World Health Organization**. Ethics and COVID-19: Resource Allocation and Priority-Setting. Geneva. c2020. https://www.who.int/ethics/publications/ethics-covid-19-resource-allocation.pdf. Accessed March 1, 2021.
19. **Australian Bureau of Statistics**. National, State and Territory Population, June 2020. Canberra: 2020. https://www.abs.gov.au/statistics/people/population/national-state-and-territory-population/latest-release. Accessed February 24, 2021.
20. **Australian Institute of Health and Welfare**. Aged care data snapshot—2020. GEN. https://gen-agedcaredata.gov.au/Resources/Access-data/2020/October/Aged-care-data-snapshot%E2%80%942020. Accessed February 24, 2021.
21. **Australian Institute of Health and Welfare**. Aged care service list: 30 June 2020. GEN. https://gen-agedcaredata.gov.au/Resources/Access-data/2020/October/Aged-care-service-list-30-June-2020. Accessed February 24, 2021.
22. **Australian Institute of Health and Welfare**. Hospital resources 2017-18: Australian hospital statistics. 2019. https://www.aihw.gov.au/reports/hospitals/hospital-resources-2017-18-ahs/data. Accessed February 24, 2021.
23. **Australian Government**. My aged care. https://www.myagedcare.gov.au/. Accessed February 24, 2021.
24. **Australian Bureau of Statistics**. Postal Area, Indexes, SEIFA 2016. 2018. https://www.abs.gov.au/ausstats/subscriber.nsf/log?openagent&2033055001%20-%20poa%20indexes.xls&2033.0.55.001&Data%20Cubes&DC124D1DAC3D9FDDCA25825D000F9267&0&2016&27.03.2018&Latest. Accessed February 24, 2021.
25. **Department of Health (AU)**. Modified Monash Model (MMM) suburb and locality classification – home care subsidy. 2019. https://www.health.gov.au/resources/publications/modified-monash-model-mmm-suburb-and-locality-classification-home-care-subsidy. Accessed February 24, 2021.
26. **Department of Health (AU)**. Modified Monash Model. 2019. Accessed May 21, 2021. https://www.rdaa.com.au/documents/item/740. Accessed June 30, 2021.
27. **Farm Transparency Project**. Farm Transparency Project. Accessed February 24, 2021. https://www.farmtransparency.org/. Accessed June 30, 2021.
28. **Department of Health (AU)**. CDNA national guidelines for the prevention, control and public health management of COVID-19 outbreaks in residential care facilities in Australia. 2020. https://www.health.gov.au/resources/publications/cdna-national-guidelines-for-the-prevention-control-and-public-health-management-of-covid-19-outbreaks-in-residential-care-facilities-in-australia. Accessed February 23, 2021.
29. **Abrams HR, Loomer L, Gandhi A, *et al.*** Characteristics of U.S. nursing homes with COVID-19 cases. *J Am Geriatr Soc.* 2020;68(8):1653-1656. doi: 10.1111/jgs.16661
30. **Sugg MM, Spaulding TJ, Lane SJ, *et al.*** Mapping community-level determinants of COVID-19 transmission in nursing homes: a multi-scale approach. *Sci Total Environ.* 2021;752:141946. doi: 10.1016/j.scitotenv.2020.141946
31. **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(4):439-448. doi: 10.1001/jamainternmed.2020.7968