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Original Article

In-hospital mortality in patients admitted to Australian intensive care units with COVID-19 between 2020 and 2024

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ABSTRACT

Objective: To describe and compare the demographics, management, and outcomes for patients with COVID-19 admitted to intensive care units (ICUs) in Australia across the various waves of the COVID pandemic.

Design, setting, and participants: People aged ≥16 years who were admitted to a participating ICU with confirmed COVID-19 in the Short Period Incidence Study of Severe Acute Respiratory Infection (SPRINT-SARI) Australia study between February 2020 and May 2024.

Main outcome measures: Primary outcome: In-hospital mortality. Secondary outcomes: ICU mortality; ICU and hospital lengths of stay; supportive and disease-specific therapies.

Results: From 27 February 2020 to 18 May 2024, 10171 people were admitted to 72 ICUs with confirmed COVID-19 disease. The *Wild Type* wave included 518 (5.1%) patients, the *Delta* wave 2467 (24.3%) patients, and the *Omicron* wave 7186 (70.7%) patients. The median (IQR) age was 61 (49–70) years, 54 (41–66) years, and 65 (45–75) years, respectively ($P < 0.001$). The proportion of vaccinated cases increased in successive waves (1% vs 23.9% vs 65.1%) but plateaued in the *Omicron* subvariant waves (range 60.0%–71.9%). Invasive mechanical ventilation use decreased across successive waves (52.5% vs 43.6% vs 31.7%, $P < 0.001$). Use of extracorporeal membrane oxygenation was highest during the *Delta* wave (3.6%, 83 patients, median duration 18 days [IQR 9.8–35]). Multivariable analysis demonstrated an increased risk of in-hospital

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mortality among patients admitted during the *Delta* (adjusted HR 1.80, 95% CI: 1.38–2.35, $p < 0.001$) and *Omicron* (adjusted HR 1.88, 95% CI: 1.46–2.42, $p < 0.001$) waves when compared to the *Wild Type* wave.
Conclusion: COVID-19 continues to manifest significant morbidity and mortality in those requiring ICU admission. Despite a reduced need for ICU level supports, patients admitted during the *Omicron* wave demonstrated the highest in-hospital mortality.

1. Introduction

The COVID-19 pandemic in Australia has been defined by distinct waves of disease, each characterised by different patient characteristics and clinical outcomes, and the emergence of a dominant circulating viral variant. The *Omicron* variant was first detected in Botswana and South Africa in November 2021,[1,2] with the first case detected soon after in Sydney in December 2021. The *Omicron* variant has been the dominant strain in Australia since this time, with multiple waves of Omicron subvariants over the past three years.

Mutations in the COVID-19 viral spike protein have led to higher transmissibility than previous strains.[1] This, along with other public health factors, such as variable vaccination rates, changes in testing and community health measures, have resulted in a high degree of community spread of the *Omicron* variant. Globally, compared to the preceding *Delta* wave, infection with the *Omicron* variant has been reported to cause less severe illness, with lower rates of hospitalisation and mortality.[3–10]

However, to date, there is limited data on the impact of *Omicron* across Australia in comparison to the preceding waves, in particular in those requiring admission to intensive care units (ICUs). As such, the aim of this study was to compare and contrast the demographic features, clinical presentation, management, and outcomes for patients admitted with COVID-19 to ICUs across all waves of the COVID-19 pandemic in Australia. Our primary hypothesis was that the *Omicron* variant was associated with higher adjusted in-hospital mortality in patients admitted to ICU despite changing disease characteristics and widespread vaccination.

2. Methods

2.1. Study design

Short PeRiod IncideNce sTudy of Severe Acute Respiratory Infection (SPRINT-SARI) Australia is a multicentre, prospective, observational cohort study of patients with COVID-19 admitted to ICUs across Australia. The study is supported by the Australian and New Zealand Intensive Care Society (ANZICS) Clinical Trials Group and coordinated by the Australian and New Zealand Intensive Care Research Centre (ANZIC-RC) at Monash University. The study design has been described previously.[11,12] The various 'waves' of the COVID-19 pandemic have been defined in national reports by the Australian Commonwealth according to the predominant circulating strain in the community (see Supplementary Table 1). The first period, or *Wild Type* wave is defined as occurring between 25 January 2020 and 15 June 2021, the second period, or *Delta* wave is defined as between 16 June 2021 and 14 December 2021, and the third period, or *Omicron* wave is defined as between 15 December 2021 to present. The *Omicron* wave is further broken into the *Omicron 1* (*BA.1)* wave between 15 December 2021 and 28 February 2022, the *Omicron 2* (*BA.2*) wave between 29 February 2022 and 14 June 2022, the *Omicron 3 (BA.5)* wave between 15 June 2022 and 23 October 2022, the *Omicron 4 (combination and newly emerging)* wave between 24 October 2022 and 28 February 2023, the *Omicron 5* (*combination and newly recombinant)* wave between 1 March 2023 and 13 August 2023, and the *Omicron 6* (*combination and newly recombinant)* wave between 14 August 2023 and present (18 May 2024 in this study). Patient outcome data were extracted on 22 August 2024. For the purposes of this analysis, the *Omicron* waves were combined, although data for all sub-variants is provided in the Supplementary material.

2.2. Outcomes

The primary outcome was in-hospital mortality. Secondary outcomes included ICU mortality; ICU and hospital lengths of stay, and need for supportive and disease-specific therapies.

2.3. Statistical analysis

Data were stratified by COVID-19 wave. We present descriptive statistics with continuous variables reported as median (interquartile ranges, IQR) and categorical variables as proportions (percentage). Comparisons between waves were assessed with ANOVA (continuous variables) or chi-square tests (categorical variables). In-hospital mortality was explored using a multivariable analysis using a cox regression model and logistic regression model with missing data handled using multiple imputation. Results from the model are presented as adjusted hazard ratio (HR) for Cox regression and odds ratios (OR) for logistic regression with 95% confidence intervals. Variables included in the model were: COVID waves, body mass index (BMI), number of comorbidities, invasive ventilation and incidental COVID diagnosis. A P-value <0.05 was considered statistically significant, with no correction applied for multiplicity. All statistical analyses were performed using R statistical software (v4.2.2).[13]

The Alfred Health Human Research Ethics Committee approved data collection and analysis for this study. The requirement for informed consent by individual patients was waived (HREC/16/Alfred/59).

3. Results

3.1. Overall patient and admission characteristics

Between 27 February 2020 and 18 May 2024, 10171 patients with polymerase chain reaction (PCR) or rapid antigen test (RAT) confirmed SARS-CoV-2 infections were admitted to 72 of the 78 ICUs participating in SPRINT-SARI Australia. The number of admissions in the three waves increased over time: 518 (5.1 %) were admitted in the *Wild Type* wave, 2467 (24.3 %) in the *Delta*, and 7186 (70.7 %) in the *Omicron* waves (Fig. 1 and Supplementary Fig. 1). Baseline characteristics are presented in Table 1. Mean patient age in the *Wild Type* wave was 61 (IQR 49–70) years. Patients in the *Delta* wave were the youngest (54 years [IQR 41–66]), while patients admitted in the *Omicron* wave were the oldest (65 years [IQR 48–75]). The proportion of patients over 80 years old also varied,

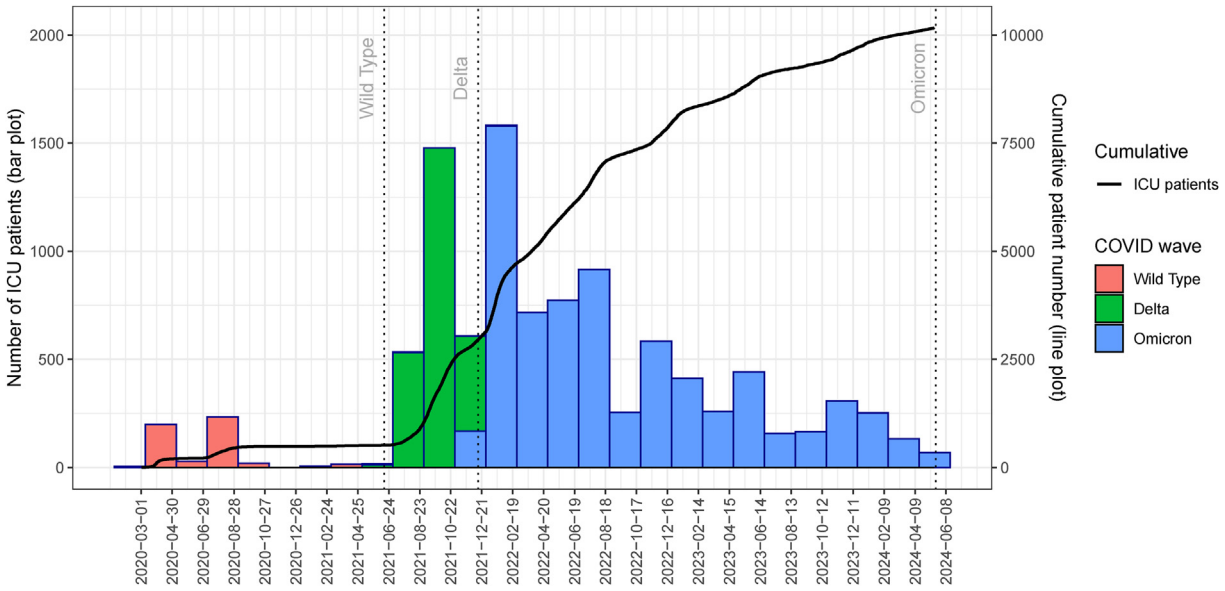

Fig. 1. Cumulative patients admitted to ICU with COVID-19.

and was greatest in the *Omicron* wave (985/7186 [13.7%]), compared with the *Wild Type* (26/518 [5.0%]) and *Delta* waves (84/2467 [3.4%]), $p < 0.001$. The proportion of cases with a history of having received any vaccination increased with each subsequent wave (*Wild Type* 5/518 [1.0%] vs *Delta* 589/2467 [23.9%] vs *Omicron* 4677/7186 [65.1%], $p < 0.001$). Rates of chronic diseases, such as chronic cardiac failure and chronic obstructive pulmonary disease (COPD), immunosuppression, chronic kidney disease and cancer increased with each subsequent wave, while rates of obesity decreased.

3.2. Subgroup analysis of the Omicron wave

Subgroup analysis of the *Omicron* wave showed that while patient age remained similar across the wave (albeit higher than in the previous waves), the numbers of patients with multiple comorbidities (including chronic cardiac failure, chronic obstructive pulmonary disease and malignancy) increased over time (Supplementary Table 2). Vaccination rates peaked in the 4th *Omicron* subvariant wave (732/1017 [71.9%]), and then fell to 590/937 (63%) in the most recent 6th *Omicron* subvariant wave.

3.3. Interventions and complications

COVID treatments and ICU interventions varied significantly across the COVID waves (Table 2 and Supplementary Table 3). Rates of antibiotic prescriptions were highest in the *Wild Type* wave (82.8 %), and lowest in the *Delta* wave (21.8 %). The use of corticosteroids peaked in the *Delta* wave (81.4%) and then fell in the *Omicron* wave (65.9%). Use of remdesivir peaked in the *Wild Type* wave (29.4%), while tocilizumab use was highest in the *Delta* wave (11.6%) ($p < 0.01$ for all comparisons).

Rates of invasive ventilation declined across subsequent pandemic waves from a peak of 52.5% in the *Wild Type* wave, with 43.6% in the *Delta* wave, and 31.7% in the *Omicron* waves ($p < 0.001$) (Supplementary Table 4). Duration of invasive mechanical ventilation was also highest in the *Wild Type* wave (median 10 days, IQR 5–16 days), although prone positioning was used most in the *Delta* wave (55.2%). Need for extracorporeal membrane oxygenation (ECMO) was highest during the *Delta* wave (3.6%, 83 patients), with a median duration of 18 days (IQR 9.8–35).

3.4. Outcomes

The median (IQR) hospital length of stay reduced over time following the *Wild Type* wave (15 days [8.6–25] vs 14 days [8.6–24] vs 10 days [6.6–19], $p < 0.001$). While ICU mortality was similar across the respective waves (*Wild Type* 11.6% vs *Delta* 12.4% vs *Omicron* 12.1%, P = 0.8619), in-hospital mortality was highest in the *Omicron* wave (65/518 [12.5%] vs 355/2467 [14.4%] vs 1219/7186 [17%], $p < 0.001$) (Table 3).

Cox regression with multiple imputation for missing data demonstrated an increased risk of in-hospital mortality among patients admitted during the *Delta* (adjusted HR 1.80, 95% CI: 1.38–2.35, $p < 0.001$) and *Omicron* (adjusted HR 1.88, 95% CI: 1.46–2.42, $p < 0.001$) waves when compared to the *Wild Type* wave (Fig. 2). In-hospital mortality was higher in patients over 60 years, with a greater risk seen in successive age brackets (aged 60–69 years [adjusted HR 2.13, 95% CI: 1.84–2.47, $p < 0.001$], 70–79 years [adjusted HR 3.11, 95% CI: 2.69–3.59, $p < 0.001$], and over 80 years [adjusted HR 4.36, 95% CI: 3.68–5.17, $p < 0.001$]). Obesity was found to be protective against death, while a greater number of comorbidities were associated with an increased risk of mortality (Fig. 2). Need for invasive ventilation was associated with a higher risk of in-hospital mortality (adjusted HR 2.01, 95% CI: 1.81–2.23, $p < 0.001$). These results were validated by Cox regression model without missing data imputation (Supplementary Fig. 6), and logistic regression of in-hospital mortality (Supplementary Fig. 7). Adjusted survival probability following ICU admission, stratified by COVID-19 wave is presented in Fig. 3 (and Supplementary Fig. 8).

3.5. Subgroup analysis of the Omicron wave

Subgroup analysis of the *Omicron* wave showed variation in mortality between sub-variants; however, all displayed higher mortality than the *Wild Type* wave (Supplementary Fig. 2). The highest mortality occurred with the first *Omicron* subvariant (adjusted HR 2.21, 95% CI: 1.69–2.88, $p < 0.001$), with mortality subsequently decreasing over time. Age >60 (adjusted HR 2.74, 95% CI: 2.04–3.01, $p < 0.01$) and the presence of mechanical ventilation (adjusted HR 1.96, 95% CI: 1.76–2.18, $p < 0.001$) were associated with an increased hazard of in-hospital death. When compared with patients admitted during the *Delta* wave,

Table 1
Characteristics of patients admitted to SPRINT-SARI intensive care units with COVID-19.

	Wild Type (N = 518)	Delta (N = 2467)	Omicron (N = 7186)	Overall (N = 10171)	P-value
Sex − Male	334 (64.5%)	1492 (60.5%)	4330 (60.3%)	6156 (60.5%)	0.17
Age at admission, median [IQR]	61 [49, 70]	54 [41, 66]	65 [48, 75]	62 [46, 73]	<0.001
Age group at admission					<0.001
< 60	247 (47.7%)	1515 (61.4%)	2879 (40.1%)	4641 (45.6 %)	
60 - 69	135 (26.1%)	528 (21.4%)	1513 (21.1%)	2176 (21.4 %)	
70 - 79	110 (21.2%)	338 (13.7%)	1807 (25.1%)	2255 (22.2 %)	
> 80	26 (5.0%)	84 (3.4%)	985 (13.7%)	1095 (10.8%)	
BMI at admission					<0.001
Median [IQR]	30 [26, 35]	31 [27, 37]	28 [24, 33]	29 [25, 34]	
Missing	63 (12.2%)	700 (28.4%)	2368 (33.0%)	3131 (30.8%)	
BMI group					<0.001
Underweight	7 (1.4%)	12 (0.5%)	273 (3.8%)	292 (2.9%)	
Normal weight	94 (18.1%)	245 (9.9%)	1327 (18.5%)	1666 (16.4%)	
Overweight	133 (25.7%)	485 (19.7%)	1435 (20.0%)	2053 (20.2%)	
Obese - Class I	113 (21.8%)	464 (18.8%)	870 (12.1%)	1447 (14.2%)	
Obese - Class II	61 (11.8%)	242 (9.8%)	445 (6.2%)	748 (7.4%)	
Obese - Class III	47 (9.1%)	319 (12.9%)	468 (6.5%)	834 (8.2%)	
Not stated	63 (12.2%)	700 (28.4%)	2368 (33.0%)	3131 (30.8%)	
Received COVID-19 vaccine					<0.001
Yes	5 (1.0%)	589 (23.9%)	4677 (65.1%)	5271 (51.8%)	
No	506 (97.7%)	1595 (64.7%)	1369 (19.1%)	3470 (34.1%)	
Missing	7 (1.4%)	283 (11.5%)	1140 (15.9%)	1430 (14.1%)	
Doses of COVID-19 vaccine					<0.001
0	506 (97.7%)	1595 (64.7%)	1369 (19.1%)	3470 (34.1%)	
1	2 (0.4%)	405 (16.4%)	149 (2.1%)	556 (5.5%)	
2	2 (0.4%)	180 (7.3%)	1590 (22.1%)	1772 (17.4%)	
3	0 (0%)	4 (0.2%)	1694 (23.6%)	1698 (16.7%)	
4	0 (0%)	0 (0%)	943 (13.1%)	943 (9.3%)	
5	1 (0.2%)	0 (0%)	226 (3.1%)	227 (2.2%)	
6	0 (0%)	0 (0%)	33 (0.5%)	33 (0.3%)	
Missing	7 (1.4%)	283 (11.5%)	1182 (16.4%)	1472 (14.5%)	
Time since last dose					<0.001
within 7 days	0 (0%)	67 (2.7%)	49 (0.7%)	116 (1.1%)	
7−14 days	0 (0 %)	105 (4.3%)	76 (1.1%)	181 (1.8%)	
More than 14 days	4 (0.8 %)	269 (10.9%)	4118 (57.3%)	4391 (43.2%)	
Missing	514 (99.2%)	2026 (82.1%)	2943 (41.0%)	5483 (53.9%)	
Number of co-exiting disorders					<0.001
0	154 (29.7%)	942 (38.2%)	2282 (31.8%)	3378 (33.2%)	
1	135 (26.1%)	665 (27.0%)	1321 (18.4%)	2121 (20.9%)	
2	115 (22.2%)	433 (17.6%)	1252 (17.4%)	1800 (17.7%)	
≥3	114 (22.0%)	427 (17.3%)	2331 (32.4%)	2872 (28.2%)	
Diabetes	156 (30.1%)	608 (24.6%)	1805 (25.1%)	2569 (25.3%)	<0.001
Obesity	136 (26.3%)	675 (27.4%)	1018 (14.2%)	1829 (18.0%)	<0.001
Use of ACEi or ARB	102 (19.7%)	394 (16.0%)	1342 (18.7%)	1838 (18.1 %)	0.0066
Chronic cardiac failure	73 (14.1%)	259 (10.5%)	1659 (23.1%)	1991 (19.6%)	<0.001
Smoker	63 (12.2%)	340 (13.8%)	1270 (17.7%)	1673 (16.4%)	<0.001
Chronic pulmonary disease	43 (8.3 %)	141 (5.7%)	1004 (14.0%)	1188 (11.7%)	<0.001
Asthma	66 (12.7%)	237 (9.6%)	618 (8.6%)	921 (9.1%)	0.0036
Immunosuppression	36 (6.9%)	100 (4.1%)	989 (13.8%)	1125 (11.1%)	<0.001
Chronic kidney disease	31 (6.0%)	129 (5.2%)	906 (12.6%)	1066 (10.5%)	<0.001
Chronic heamatological disease	15 (2.9%)	35 (1.4%)	471 (6.6%)	521 (5.1%)	<0.001
Cancer	17 (3.3%)	40 (1.6%)	585 (8.1%)	642 (6.3%)	<0.001

Table 2
Interventions and complications.

	Wild Type (N = 518)	Delta (N = 2467)	Omicron (N = 7186)	Overall (N = 10171)	P-value
Antibiotics	429 (82.8%)	538 (21.8%)	3761 (52.3%)	4728 (46.5%)	<0.001
Steroids	319 (61.6%)	2008 (81.4%)	4733 (65.9%)	7060 (69.4%)	<0.001
Remdesivir	152 (29.3%)	245 (9.9%)	27 (0.4%)	424 (4.2%)	<0.001
Tocilizumab	4 (0.8%)	286 (11.6%)	367 (5.1%)	657 (6.5%)	<0.001
JAK inhibitor	3 (0.6 %)	1100 (44.6%)	1520 (21.2%)	2623 (25.8%)	<0.001
Invasive ventilation	272 (52.5%)	1076 (43.6%)	2279 (31.7%)	3627 (35.7%)	<0.001
Duration of ventilation, median [IQR] days	10 [5.0, 16]	8.7 [4.7, 15]	3.4 [1.3, 7.7]	5.1 [1.9, 11]	<0.001
Prone positioning	160 (30.9%)	1362 (55.2%)	1005 (14.0%)	2527 (24.8%)	<0.001
Awake prone	71 (13.7 %)	673 (27.3%)	348 (4.8%)	1092 (10.7%)	<0.001
Renal replacement therapy	48 (9.3 %)	138 (5.6%)	611 (8.5%)	797 (7.8%)	<0.001
ECMO	15 (2.9%)	88 (3.6%)	55 (0.8%)	158 (1.6%)	<0.001
Duration of ECMO, median [IQR] days	16 [4.5, 21]	18 [9.8, 35]	9.7 [3.7, 18]	14 [6.1, 30]	0.0053

Table 3
Clinical outcomes.

	Wild Type (N = 518)	Delta (N = 2467)	Omicron (N = 7186)	Overall (N = 10171)	P-value
Duration of ventilation, days					
Median [IQR]	10 [5.0, 16]	8.7 [4.7, 15]	3.4 [1.3, 7.7]	5.1 [1.9, 11]	<0.001
Missing	3 (1.1%)	90 (8.36%)	54 (2.37%)	147 (4.05%)	
ICU length of stay, days					
Median [IQR]	6.5 [2.7, 15]	5.9 [2.7, 12]	3.1 [1.6, 6.8]	3.8 [1.8, 8.5]	<0.001
Missing	7 (1.4%)	74 (3.0%)	86 (1.2%)	167 (1.6%)	
Hospital length of stay, days					
Median [IQR]	15 [9.0, 26]	14 [8.7, 24]	11 [5.6, 20]	12 [6.3, 21]	<0.001
Missing	8 (1.5%)	119 (4.8%)	125 (1.7%)	252 (2.5%)	
ICU mortality - no. (%)	60 (11.6%)	305 (12.4%)	867 (12.1%)	1232 (12.1%)	0.8619
Hospital ward mortality - no. (%)	5 (1.0%)	50 (2.0%)	352 (4.9%)	407 (4.0%)	<0.001
Overall in hospital mortality - no. (%)	65 (12.5%)	355 (14.4%)	1219 (17%)	1639 (16.1%)	<0.001

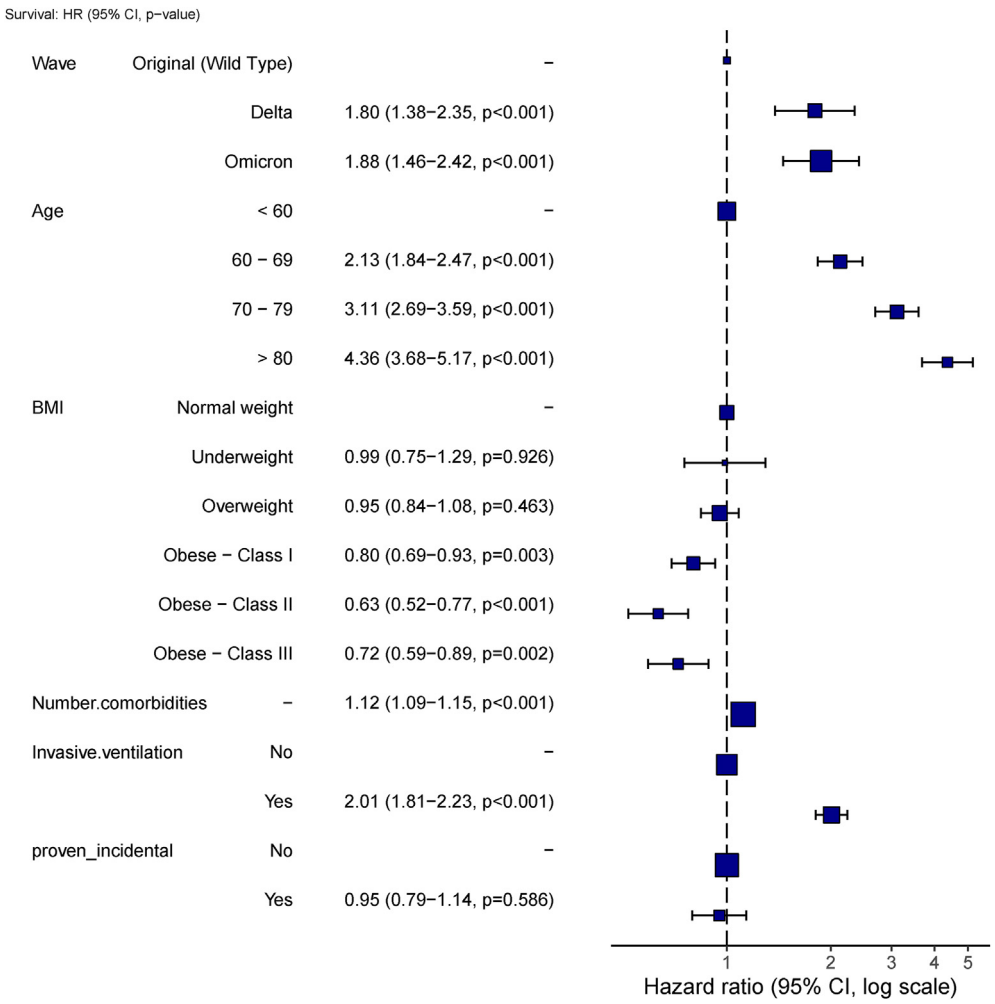

Fig. 2. Multivariable analysis (Cox regression) of in-hospital mortality. *Reference: Wild Type wave.*

mortality was similar for all *Omicron* subvariant waves aside from the BA.1 variant, which was associated with higher mortality (adjusted HR 1.21, 95% CI 1.05–1.41, $p = 0.011$) (Supplementary Fig. 3). In-hospital mortality has decreased over the *Omicron* period. When compared to the initial *Omicron* wave, the two most recent *Omicron* waves (encompassing a period of March 2023 to May 2024) have demonstrated reduced chance of death (adjusted HR 0.72, 95% CI: 0.58–0.89, $p = 0.002$) (Supplementary Figs. 4 and 5).

4. Discussion

In our analysis of the nationally representative SPRINT SARI database, we have shown that patients with the *Omicron* variant were older and have higher rates of comorbidities compared to the *Wild Type* and *Delta* variants. The use of mechanical ventilation and other treatments such as proning and ECMO have decreased, as have duration of mechanical ventilation, and ICU length of stay. Despite this, overall crude and adjusted hospital mortality has

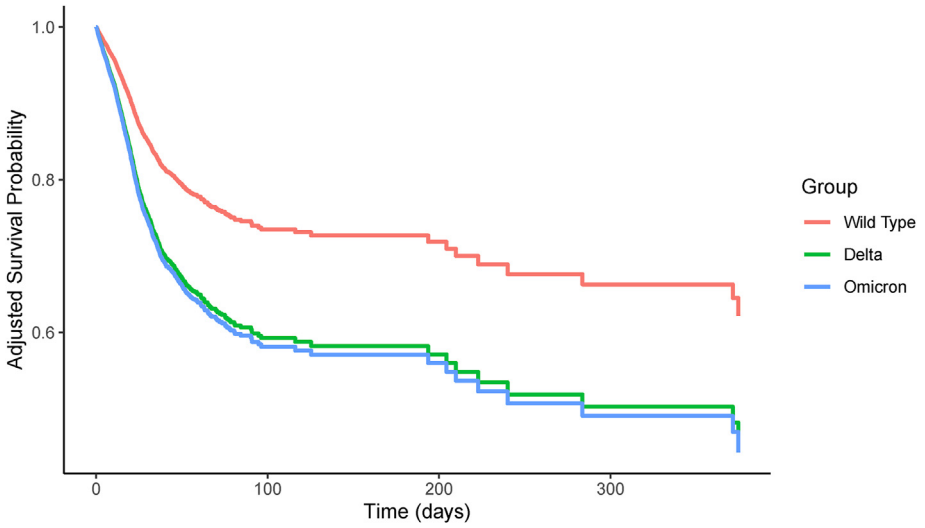

Fig. 3. Adjusted survival probability following ICU admission with COVID-19.

increased with the *Omicron* variant (particularly the *Omicron BA.1* sub-variant) compared to the preceding waves.

4.1. Relationship to prior literature

Population-level data suggest that *Omicron* causes milder disease with lower rates of mortality and admission to ICU. In Australia, the case-fatality rate for the *Omicron* variant is lower than the *Delta* variant (0.19% and 0.71%, respectively).[10] Internationally, a systematic review and meta-analysis comparing 895,201 patients hospitalised with the *Omicron BA.1 or BA.2* variant, and 3,916,745 patients with *Delta* also found a lower risk of ICU admission, need for oxygen therapy or invasive mechanical ventilation and death (RR 0.39, 95 % CI 0.33–0.46).[14]

Similarly, studies of ICU populations with *Omicron* suggest that the mortality rate is also lower or similar to previous waves. A Brazilian study evaluating outcomes of patients admitted to ICU with COVID-19 found that the period of *Omicron* dominance was associated with lower 60-day mortality compared to the *Wild Type* and *Delta* periods (adjusted OR 0.51, 95% CI: 0.29–0.90, and adjusted OR 0.32, 95% CI: 0.18–0.56, respectively).[15] A Dutch cohort study examined outcomes of more than 18,000 patients admitted to ICU across the pandemic.[16] The authors stratified outcomes according to time periods correlating with various waves between February 2020 and January 2023, describing the dominant circulating variant of each epoch. They found a decrease in in-hospital mortality during the three periods corresponding to *Omicron* dominance (adjusted OR 0.81, 95% CI: 0.64–1.01; adjusted OR 0.48, 95% CI: 0.33–0.69; and adjusted OR 0.48, 95% CI: 0.34–0.68).[16] A prospective cohort study, consisting of 259 patients admitted to 20 ICUs in France between 7 December 2021 and 1 May 2022, found no significant difference between *Delta* and *Omicron* variant 28-day mortality (adjusted OR 0.68, 95% CI: 0.35–1.32, $p = 0.253$).[17] However, our findings suggest that for the population that is admitted to intensive care unit, the *Omicron* variant carries a greater risk of death compared to the preceding waves, even after adjustment for baseline differences (Fig. 2).

The population admitted to ICU in Australia during *Omicron* was older and more comorbid, with higher rates of smokers, chronic obstructive pulmonary disease, and other chronic medical conditions. Rates of immunosuppression were also highest in the *Omicron* waves– and there are data to suggest immunosuppressed patients respond differently to COVID-19 infection.[18] Mortality rates were higher with increasing age, in keeping with previous studies demonstrating that older age is highly predictive for increased death in ICU with COVID-19.[19] Mechanical ventilation was also strongly associated with increased risk of death; however, the overall rate of mechanical ventilation decreased over the subsequent waves.

Australia's COVID-19 vaccination program has been viewed as a success, with high vaccine coverage and effectiveness,[20] and an estimated 6-fold reduction in expected mortality observed in New South Wales alone.[21] While the proportion of those admitted to ICU who were vaccinated was higher during the *Omicron* wave than during the first two waves, rates have plateaued over the subsequent *Omicron* subvariant waves. Despite national recommendations for annual COVID booster vaccinations, as of June 2024, only 4.2% of Australians aged 18–64 years, 25.5% aged 65–74 years, and 38.2% aged 75 years and older had received a dose in the past 6 months. Partial vaccination rates, lack of widespread adoption of COVID booster vaccinations, and waning immunity over time may be contributing to the increased rates of mortality seen in our *Omicron* population, with the selection out of a vulnerable population admitted to ICU. Despite this, when compared to the initial *Omicron* variant, there appears to be a gradual reduction in mortality over the *Omicron* subvariant waves.

4.2. Study implications

Our findings demonstrated that despite lower case fatality rates in the community, admission to ICU with COVID-19 during the *Omicron* wave was associated with the highest mortality rate, even after adjusting for baseline differences. We hypothesise that this was largely driven by the susceptible population admitted to ICU and reinforces the importance of ongoing measures in the community, such as targeted vaccination programs and health care resourcing.[22]

4.3. Strengths and limitations

The majority of sites contributing to SPRINT-SARI do not record the variant type or sub-type of COVID-19. As such, we are reliant on Commonwealth-generated reference data regarding the dominant circulating strain and can only infer that patients admitted between the stated timepoints were infected with a particular strain of virus.

This has been a commonly used methodology across the COVID-19 pandemic.[16,19,23]

While SPRINT-SARI collects data from 78 ICUs across Australia, this does not include every patient in every ICU with COVID-19. We acknowledge a degree of missingness with regards to several variables, including time from vaccination and BMI, albeit we have used multiple imputation to account for this. We also do not collect long-term outcomes; therefore cannot comment on the potential changes in long-term mortality of patients admitted to ICU with COVID-19. Given the lower need for hospital and intensive care admission seen among patients with *Omicron*,[5,14,24–26] and the community data suggesting lower overall mortality,[10] it is likely that the overall risk of mortality for *Omicron* is lower than what is reflected in our data. Despite this, for those who require admission to intensive care with COVID-19, the *Omicron* variant has a significant risk of death.

The management of COVID-19 has evolved substantially over the course of the pandemic. Both molnupiravir (Lagevrio) and nirmatrelvir plus ritonavir (Paxlovid) became available on the pharmaceutical benefits scheme (PBS) during the *Omicron* waves. No data on the pre-hospital or in-ICU use of these medications was captured in this study. Additionally, we did not collect data on pre- or post-ICU care (outside of hospital length of stay and in-hospital mortality), therefore cannot comment on the potential impact of changes in practice outside of intensive care. Finally, patients may be admitted to ICU for a variety of reasons, outside the need for ICU level supports – including the need for single-room isolation, hospital bed-pressure and emergency department flow. These outside influences have changed over various stages of the pandemic. As such, we cannot rule out significant selection bias confounding the results of this study.

Due to constraints imposed on data collection during the pandemic, we were unable to consistently obtain information concerning the degree of physiological derangement at ICU admission. As such, with increasing clinical demand, it may be that only more severely unwell patients were admitted to ICU, confounding the association with in-hospital mortality. Of note, however, is the lower proportion of patients receiving invasive ventilation during Omicron, as compared with the Wild Type wave. Similarly, we do not report data on overall ICU occupancy during these periods, and therefore cannot more thoroughly explore the impact of organisational strain on individual patient outcomes.

4.4. Conclusions

COVID-19 continues to manifest significant morbidity and mortality in those requiring ICU admission. Despite a reduced need for ICU level supports, patients admitted during the *Omicron* wave demonstrated the highest in-hospital mortality.

Author contribution statement

MTD, PZ, AU and AB were involved in the study design and preparation of the manuscript. PZ performed the statistical analysis. All authors approved the final manuscript.

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: SPRINT-SARI Australia reports financial support was provided by Department of Health, Commonwealth of Australia. Andrew Udy, Mark Plummer and Edward Litton declare they are part of the CC&R editorial team as associate editors. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ccrj.2024.11.003.

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