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ORIGINAL ARTICLE

Variation in clinical presentation, complications and outcomes for Māori and Pacific peoples among hospitalised adults with COVID-19 in 2022, Aotearoa New Zealand

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Key words
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Abstract

Background: Pacific region-specific data on the clinical course of COVID-19 are limited. We aimed to describe clinical features and outcomes from Aotearoa New Zealand patients, focusing on Māori and Pacific peoples.

Methods: We conducted a retrospective cohort study among adults (≥16 years) hospitalised due to COVID-19 at 11 hospitals from January to May 2022. We included all Māori and Pacific patients and every second non-Māori, non-Pacific (NMNP) patient using data from chart review and national datasets.

Results: Of 2319 patients, 582 (25%) were Māori, 914 (39%) Pacific peoples and 862 NMNP (median age 52, 57 and 63 years respectively). Vaccination coverage (≥2 doses) was 73.4% ($n = 437$) for Māori, 76.7% ($n = 701$) for Pacific peoples ($n = 701$) and 84.8% ($n = 731$) for NMNP. Among 832 (35.9%) with complications, Māori had a greater risk than NMNP of acute kidney injury (risk ratio (RR) 1.87, $P < 0.001$), cardiac arrhythmia (RR = 1.60, $P = 0.023$), shock (RR = 2.64, $P = 0.005$), myocardial infarction (RR 2.21, $P = 0.042$), cardiac arrest (RR 2.68, $P = 0.046$) and acute respiratory distress syndrome (RR = 2.81, $P = 0.008$). Pacific patients experienced a greater risk than NMNP of acute kidney injury (RR = 2.18, $P < 0.001$) and pneumonia (RR = 1.32, $P = 0.047$) and a lower risk of thromboembolism (RR = 0.35, $P = 0.004$) and myocarditis/pericarditis (RR = 0.23, $P = 0.003$). During admission, 23 (3.3%) Māori, 36 (3.9%) Pacific and 28 (3.2%) NMNP patients died, with no difference in age-standardised mortality.

Conclusions: The clinical course of patients hospitalised by COVID-19 varied between ethnic groups, likely reflecting differential access to social determinants of health. Healthcare services that respond to this variability are needed to achieve the highest attainable health for all.

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Introduction

COVID-19 continues to cause hospitalisation and deaths,[1] and understanding the clinical characteristics, outcomes and use of health resources is critical for planning responses to future pandemics. Although impressive in extent, existing data on COVID-19 clinical trajectories from large international cohorts,[2,3] and within Aotearoa New Zealand (NZ) early in the pandemic,[4–6] may now be less relevant. Factors such as prior infection, vaccination, changing variants of SARS-CoV-2 and evolving treatments may change presenting symptoms, complications and outcomes.[7]

Globally, indigenous peoples have experienced unjust disparities in COVID-19 vaccination status, infection, hospitalisation and mortality.[8] Existing data indicate that in NZ, Māori, the indigenous people, and Pacific Peoples experienced higher rates of hospitalisation and death than non-Māori, non-Pacific people,[9] likely due to differences in social determinants of health, as well as differential access to and quality of healthcare.[10] Understanding differences in presenting clinical features, complications and outcomes in Māori or Pacific peoples is needed to achieve health equity; yet currently there is a paucity of data.

Routinely collected national health datasets, including hospitalisations and mortality, are a valuable resource to measure health outcomes and health inequities. However, pervasive poor-quality ethnicity data limit analyses. Māori and Pacific peoples have been consistently undercounted across national data collections, leading to inaccurate estimates of health inequities.[11]

In early 2022, following the relaxation of public health measures in NZ such as reopening borders and removing travel restrictions, there was a surge in reported COVID-19 cases from ~4000 reported prior to October 2021 rising to >2 000 000 by the end of 2022.[12] During this time, the highly transmissible B1.1.529 (Omicron) variant emerged as the predominant variant in NZ and worldwide.[13] In January 2022, although there were inequities in vaccine coverage, 90% of people aged >12 years had received two doses of Pfizer/BioNTech BNT162b2 vaccine, and 27% of the population (35% of adults) had received three doses.[14] Therefore, data from NZ during this time adds to the understanding of the clinical features and severity of COVID-19 in an infection naïve but highly vaccinated population.

Our study aimed to address knowledge gaps by describing the presenting features, complications, treatment and outcomes of people hospitalised with COVID-19 in NZ for Māori, Pacific peoples and non-Māori, non-Pacific peoples. This study is part of a broader project that evaluated risk prediction scores for adults hospitalised with COVID-19 and aims to inform the equitable management of infectious diseases and future pandemic preparedness in NZ.

Materials and methods

Study design

This was a retrospective cohort study of patients hospitalised with COVID-19 from 1 January to 1 May 2022. It was conducted in 11 hospitals across eight NZ health regions: Waitematā, Auckland, Counties Manukau, Waikato, Bay of Plenty, Capital and Coast, Canterbury and Southern, providing acute hospital care to approximately 3 700 000 (73%) of 5 100 000 New Zealanders. Our study was centred on Te Tiriti o Waitangi (the founding document of NZ establishing the relationship between Māori and the British Crown) in its design and implementation, specifically that the study measured Māori health outcomes and produced findings to support high-quality care for Māori. Measures included Māori health co-leadership and support from an Equity Expert Reference Group, inclusive of Māori and Pacific health expertise, to inform study design, data analysis and interpretation of findings. The study gained approval from The Northern B Health and Disability Ethics Committee (20NTB72). The study is reported according to the Consolidated Criteria for Strengthening Reporting of Health Research Involving Indigenous Peoples (CONSIDER) guidelines.[15]

Study participants

Patients were eligible for screening if they were adults (aged ≥16 years old) and hospitalised within 14 days of COVID-19 diagnosis. Hospitalisation was defined as a stay of >3 h, admission to an inpatient ward or death in hospital. Eligible patients were identified using Health Region administrative databases. The sampling strategy was determined by the aim of the broader study to evaluate risk prediction scores and resource constraints limiting the number of participants. This strategy aimed to include participants representative of cases and allowed sufficient power for risk factor analyses (presented separately).[16] In order to achieve equal explanatory power for each ethnic grouping, we enrolled all patients identified as Māori and/or Pacific peoples (based on ethnicity data in hospital administrative data sets) and every second non-Māori non-Pacific patient (ordered by admission date and time). This sampling strategy enabled evaluation of risk prediction scores by ethnic group and findings that support health gain and equity for Māori and Pacific peoples in NZ.

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Data collection

Study investigators conducted a manual case review of all eligible patients to assign attribution of hospital admissions to COVID-19 according to standard definitions as previously published.[16] Study investigators underwent training to ensure standardisation of attribution. Patients included in this analysis were those whose admission was attributable to COVID-19. This includes respiratory insufficiency, blood clots to vital organs, haemodynamic changes and other common viral symptoms, as well as patients admitted due to an exacerbation of any underlying condition where the treating clinician or study investigator considered COVID-19 contributory. Patients for whom COVID-19 was not the primary cause of admission were excluded.

Study investigators extracted data from hospital records into a case report form on a REDCap research database. Data included patient demographics, symptoms and signs on admission, comorbidities, medications, COVID-19 immunisations administered prior to admission, specific COVID-19 treatments, complications of COVID-19 and outcomes as an inpatient and at 28 days. Complications of COVID-19 were recorded based on treating physician diagnoses. In addition to physician documentation, we required that bacteraemia involved culture of a pathogenic organism from blood, cardiac arrest involved survival from a loss of circulation,, and shock was defined as sustained systolic blood pressure <90 mmHg with end-organ dysfunction ascribed to the hypotension. The data collection form is included as Appendix S2.

Records were grouped into a single case report form if patients transferred between hospitals or were discharged and readmitted within 24 h; if patients were discharged and readmitted more than 1 day later, only the first episode of care attributable to COVID-19 was included.

Data were linked via the National Hospital Identifier to existing national data collections, that is, the National Hospital Index dataset, the Mortality Collection dataset and the National Minimum Dataset (NMDS), to improve data quality for ethnicity, death and subsequent readmissions. To minimise the impact of known undercounting of Māori and Pacific peoples in national health data collections, an 'ever-Māori' and 'ever-Pacific person' approach was used[17]: participants were classified as Māori or Pacific peoples if they had been identified as Māori or Pacific peoples in any of the national data collections used in the study.

Statistical analysis

The statistical analysis was conducted in R Studio version 2023.09.1 + 494. Descriptive analyses (counts and percentages, medians and interquartile ranges (IQRs)) were used to summarise the key variables in tables and figures using pooled data. Age standardisation to the age structure of the Māori patients included in the study was conducted to remove age as a confounding factor when exploring variations in outcomes by ethnicity. Age adjustment was performed using directly standardised rates with exact confidence intervals.[18] Variations in symptoms, investigations, treatment and outcomes were assessed using rate ratios. Rate ratios were not calculated if the total number of events was <20, due to risks of unstable estimates and were not estimated for baseline data of events prior to hospitalisation due to likelihood of confounding.

Ethnic group categories were defined to enable the identification of Māori and Pacific health inequities. Ethnicity is reported as (i) Māori, (ii) Pacific peoples and (iii) non-Māori, non-Pacific using total response ethnicity, meaning that individuals are counted in each ethnic group that they belong to. For example, patients who identified as both Māori and Pacific peoples were included in both Māori and Pacific ethnic groups. The non-Māori, non-Pacific group is mutually exclusive of the Māori and Pacific peoples groups. Total response, as described in NZ HISO Ethnicity Data Protocols,[19] was used to represent the diversity of Māori and Pacific peoples.

Results

Of 4459 patients hospitalised within 14 days of COVID-19 diagnosis, 2319 (52.0%) patients were admitted due to COVID-19 and therefore included in this analysis. Demographic characteristics and vaccination status are shown in Table 1. Among the patients, 2054 (88.6%) identified with a single ethnicity. There were 40 (1.7%) patients who identified as both Māori and Pacific and were included in both groups. The median (IQR) age of patients was 51.5 (34.0–65.0) for Māori, 57.0 (37.0–72.0) for Pacific peoples and 63.0 (40.0–78.0) for non-Māori, non-Pacific. Overall, 78.8% ($n = 1828$) of patients had received ≥2 vaccine doses prior to admission, with ≥2 doses of COVID-19 vaccine received by 73.4% ($n = 437$) of Māori, 76.7% ($n = 701$) of Pacific peoples ($n = 701$) and 84.8% ($n = 731$) of NMNP patients.

Patient comorbidities are shown in Table 2 with 1864 (80.4%) patients having at least one of the listed comorbidities. Although individual immunosuppressing conditions were uncommon, together 320 (13.8%) patients were immunosuppressed due to an underlying condition or medication. Chronic pulmonary disease ($n = 240$ (41.5%)) was the most common comorbidity for Māori

Table 1 Demographic characteristics and site location of adults admitted to hospital due to COVID-19 by Māori, Pacific and non-Māori, non-Pacific in Aotearoa New Zealand, 2022

Characteristic	Missing data, *n* (%)	Māori	Pacific peoples	Non-Māori non-Pacific
Number of admissions (%)	—	582 (25.1%)	914 (39.4%)	862 (37.2%)
Site				
Waitematā	—	51 (8.8%)	137 (15.0%)	155 (18.0%)
Auckland	—	98 (16.8%)	273 (29.9%)	165 (19.1%)
Counties-Manukau	—	110 (18.9%)	395 (43.2%)	91 (10.6%)
Waikato	—	145 (24.9%)	27 (3.0%)	102 (11.8%)
Bay of Plenty	—	81 (13.9%)	11 (1.2%)	106 (12.3%)
Capital and Coast	—	21 (3.6%)	26 (2.8%)	33 (3.8%)
Canterbury	—	67 (11.5%)	42 (4.6%)	181 (21.0%)
Age group at admission				
16–49 years	—	269 (46.2%)	365 (39.9%)	291 (33.8%)
50–59 years	—	116 (19.9%)	131 (14.3%)	101 (11.7%)
60–69 years	—	88 (15.1%)	156 (17.1%)	118 (13.7%)
70–79 years	—	65 (11.2%)	136 (14.9%)	155 (18.0%)
80+ years	—	44 (7.6%)	126 (13.8%)	197 (22.9%)
Female	—	358 (61.5%)	523 (57.2%)	516 (59.9%)
Male	—	224 (38.5%)	391 (42.8%)	346 (40.1%)
NZ Index of deprivation quintile	8 (0.3%)			
1	—	30 (5.2%)	18 (2.0%)	129 (15.0%)
2	—	33 (5.7%)	62 (6.8%)	164 (19.0%)
3	—	63 (10.9%)	83 (9.2%)	161 (18.7%)
4	—	142 (24.6%)	209 (23.0%)	222 (25.8%)
5	—	310 (53.6%)	535 (59.0%)	186 (21.6%)
Number of COVID-19 vaccinations				
None	—	131 (22.5%)	177 (19.4%)	113 (13.1%)
1	—	24 (4.1%)	36 (3.9%)	18 (2.1%)
2	—	230 (39.5%)	415 (45.4%)	268 (31.1%)
≥3	—	197 (33.8%)	286 (31.2%)	463 (53.7%)

Forty patients were of both Māori and Pacific ethnicity and appear in both columns. NZ Index of Deprivation is an area-based measure of socioeconomic deprivation based on Census variables, with 1 representing the least deprived areas and 10 representing the most deprived areas.

patients, physician-reported obesity ($n = 378$ (56.6%)) for Pacific patients and hypertension ($n = 314$ (36.5%)) for non-Māori, non-Pacific patients.

Symptoms of COVID-19 illness at the time of hospital admission are shown in Table 3. Cough ($n = 1465$, 63.2%), dyspnoea ($n = 1334$, 57.5%) and fever ($n = 1018$, 49.3%) were the most commonly reported symptoms for all ethnicities but were more likely among people of Māori and Pacific ethnicity. The median duration of symptoms prior to hospitalisation was 3 days (IQR 1.0–6.0) (Table 4). Tachypnoea and hypoxia were more common among Māori and Pacific patients than non-Māori, non-Pacific patients, and haemoptysis (Table 3) and pulmonary infiltrates on chest radiography were more common in Pacific peoples (Table 4). Supplemental oxygen therapy was given to 599 (25.8%) patients, 104 (4.5%) received non-invasive ventilation, and 22 (0.9%) received invasive ventilation. Compared to non-Māori non-Pacific, Māori were more likely to receive systemic corticosteroid medication (risk ratio (RR) 1.33 $P < 0.001$), antibiotic therapy (RR 1.32, $P < 0.001$), COVID-19-specific antiviral therapy (RR 1.69, $P < 0.001$) and inotrope or vasopressor treatment (RR 3.05, $P = 0.010$) (Table 5). Pacific peoples were more likely to receive anticoagulation (RR 1.18, $P < 0.001$), systemic corticosteroids (RR 1.36, $P < 0.001$), antibiotic therapy (RR 1.34, $P < 0.001$), COVID-19 antiviral therapy (RR 1.49, $P = 0.002$), COVID-19 directed immune-modulator therapy (RR 1.85, $P < 0.001$) and non-invasive ventilation (RR 2.55, $P < 0.001$).

During the index admission, 832 (35.9%) individuals experienced a complication (Table 6). The prevalence of complications increased with age: 221 (25.4%) patients aged 16–49 years, 107 (31.1%) patients aged 50–59 years, 151 (42.4%) patients aged 60–69 years, 165 (46.5%) patients aged 70–79 years and 179 (48.8%) patients aged ≥80 years experienced at least one of the listed complications. The most frequent complications were acute kidney injury in 302 (13.2%) patients and clinician diagnosed bacterial pneumonia in 222 (9.8%) patients. The prevalence of delirium increased with age from seven (0.8%) patients aged <50 years to

Table 2 Prevalence of comorbidities and risk factors for severe illness of adults admitted to hospital due to COVID-19 by Māori, Pacific and non-Māori, non-Pacific, New Zealand, 2022

	Missing data	Māori	Pacific peoples	Non-Māori non-Pacific
Number of admissions (%)	—	582 (25.1%)	914 (39.4%)	862 (37.2%)
Comorbidities				
Chronic cardiac disease	16 (0.7%)	195 (33.6%)	281 (31.1%)	228 (26.6%)
Hypertension	10 (0.4%)	220 (37.9%)	413 (45.6%)	314 (36.5%)
Peripheral vascular disease	20 (0.9%)	22 (3.8%)	56 (6.2%)	39 (4.6%)
Chronic pulmonary disease	19 (0.8%)	240 (41.5%)	248 (27.5%)	243 (28.4%)
Asthma	20 (0.9%)	129 (22.3%)	126 (14.0%)	133 (15.5%)
Obstructive sleep apnoea	42 (1.8%)	65 (11.2%)	128 (14.4%)	40 (4.7%)
Chronic kidney disease	17 (0.7%)	97 (16.7%)	219 (24.2%)	109 (12.7%)
Chronic liver disease	21 (0.9%)	29 (5.0%)	51 (5.7%)	34 (4.0%)
Cerebrovascular disease	18 (0.8%)	62 (10.7%)	96 (10.7%)	96 (11.2%)
Hemiplegia	21 (0.9%)	14 (2.4%)	19 (2.1%)	18 (2.1%)
Dementia	18 (0.8%)	27 (4.7%)	67 (7.4%)	82 (9.6%)
Chronic neurological disorder	18 (0.8%)	39 (6.7%)	42 (4.7%)	99 (11.5%)
Connective tissue disorder	21 (0.9%)	14 (2.4%)	29 (3.2%)	16 (1.9%)
Diabetes	11 (0.5%)	150 (25.8%)	380 (41.9%)	154 (17.9%)
Obesity	736 (31.7%)	128 (31.8%)	378 (56.6%)	103 (19.3%)
Smoking status	4 (0.2%)			
Never smoked	—	148 (25.5%)	383 (42.0%)	467 (54.3%)
Ex-smoker	—	219 (37.7%)	288 (31.6%)	219 (25.5%)
Current smoker	—	163 (28.1%)	94 (10.3%)	68 (7.9%)
Unknown	—	51 (8.8%)	147 (16.1%)	106 (12.3%)
Immune suppressing conditions				
Human immunodeficiency virus infection	21 (0.9%)	1 (0.2%)	0 (0.0%)	1 (0.1%)
Malignant neoplasm (active)	19 (0.8%)	28 (4.8%)	45 (5.0%)	41 (4.8%)
Leukaemia	21 (0.9%)	5 (0.9%)	11 (1.2%)	10 (1.2%)
Lymphoma	21 (0.9%)	6 (1.0%)	8 (0.9%)	12 (1.4%)
Solid organ transplant	81 (3.5%)	10 (1.8%)	39 (4.5%)	19 (2.2%)
Haematologic stem cell transplant	78 (3.4%)	2 (0.3%)	3 (0.3%)	3 (0.4%)
Other immunosuppressive disease	21 (0.9%)	13 (2.2%)	26 (2.9%)	38 (4.4%)
Immunosuppressive medications within last 3 months	23 (1.0%)	51 (8.9%)	107 (11.8%)	98 (11.4%)

Forty patients were of both Māori and Pacific ethnicity and appear in both columns.

76 (21.5%) of those aged ≥80 years and was more common in those with underlying cognitive impairment, occurring in 33.9% ($n = 59$) compared to 4.4% ($n = 94$) in those without impairment. Acute kidney injury occurred in 34.5% ($n = 143$) of those with chronic kidney disease but 8.4% ($n = 158$) of those without.

Complications varied among ethnic groups: acute kidney injury was more common among Māori (RR 1.87, $P < 0.001$) and Pacific patients (RR 2.18, $P < 0.001$) compared to non-Māori, non-Pacific patients (Table 6). Māori also experienced a greater risk of cardiac arrhythmia (RR 1.60, $P = 0.023$), shock (RR 2.64, $P = 0.005$), myocardial infarction (RR 2.21, $P = 0.042$), acute respiratory distress syndrome (RR 2.81, $P = 0.008$) and cardiac arrest (RR 2.68, $P = 0.046$). Pacific peoples experienced a greater risk of bacterial pneumonia (RR 1.32, $P = 0.047$) and a lower risk of arterial or venous thromboembolism (RR 0.35, $P = 0.004$) and myocarditis or pericarditis (RR 0.23, $P = 0.003$).

There were 402 (17.3%) patients who were readmitted within 28 days of their index hospital admission, with 18.1% of Māori and 17.6% ($n = 732$) of Pacific peoples experiencing readmission. There were 142 (6.1%) patients who died either during their hospital admission or within 28 days (Table 7). We did not identify a difference in ethnicity-specific age-standardised mortality rates or readmission rates.

Discussion

In this study, we describe the clinical course of people hospitalised due to COVID-19 in NZ in 2022 where a high proportion of the population was vaccinated against COVID-19, prior infection was uncommon, and the Omicron variant predominated.[13] Patients presented with a multisystem illness and a broad range of symptoms, and only a minority developed severe pneumonitis or required respiratory support. Few patients were

Table 3 Symptoms among adults admitted to hospital due to COVID-19 by Māori, Pacific, and non-Māori, non-Pacific, Aotearoa New Zealand, 2022

Characteristic	Descriptive				Māori compared to non-Māori, non-Pacific			Pacific compared to non-Māori, non-Pacific		
	Missing data (% overall)	Maori, $n = 582$	Pacific, $n = 914$	Non-Māori, non-Pacific, $n = 862$	RR	95% CI	*P*-value	RR	95% CI	*P*-value
Cough	5 (0.2%)	370 (64%)	648 (71%)	472 (55%)	1.12	1.03–1.21	0.008	1.26	1.18–1.35	<0.001
Shortness of breath	5 (0.2%)	367 (63%)	577 (63%)	411 (48%)	1.22	1.12–1.33	<0.001	1.23	1.14–1.33	<0.001
Fever	5 (0.2%)	279 (48%)	423 (46%)	335 (39%)	1.13	1.01–1.26	0.030	1.13	1.02–1.25	0.017
Fatigue/ malaise	5 (0.2%)	195 (34%)	317 (35%)	260 (30%)	1.09	0.94–1.26	0.3	1.13	0.99–1.29	0.065
Chest pain	5 (0.2%)	183 (32%)	247 (27%)	237 (28%)	0.98	0.84–1.14	0.8	0.90	0.78–1.04	0.2
Sore throat	5 (0.2%)	135 (23%)	218 (24%)	197 (23%)	0.89	0.74–1.07	0.2	1.01	0.86–1.18	>0.9
Coryza	5 (0.2%)	126 (22%)	196 (21%)	153 (18%)	1.11	0.91–1.36	0.3	1.18	0.98–1.41	0.079
Vomiting/nausea	5 (0.2%)	120 (21%)	149 (16%)	170 (20%)	0.95	0.77–1.16	0.6	0.80	0.66–0.97	0.022
Altered consciousness/ confusion	5 (0.2%)	45 (7.8%)	129 (14%)	134 (16%)	0.78	0.57–1.06	0.11	1.17	0.95–1.43	0.14
Headache	5 (0.2%)	113 (19%)	155 (17%)	149 (17%)	0.93	0.75–1.15	0.5	0.89	0.73–1.08	0.2
Diarrhoea	5 (0.2%)	73 (13%)	107 (12%)	78 (9.1%)	1.27	0.95–1.69	0.11	1.23	0.95–1.60	0.12
Abdominal pain	5 (0.2%)	95 (16%)	97 (11%)	82 (9.5%)	1.39	1.08–1.79	0.011	0.96	0.74–1.24	0.8
Haemoptysis	5 (0.2%)	22 (3.8%)	53 (5.8%)	11 (1.3%)	1.57	0.90–2.73	0.11	2.98	1.81–4.91	<0.001
Anosmia	5 (0.2%)	16 (2.8%)	50 (5.5%)	11 (1.3%)	1.22	0.66–2.28	0.5	3.13	1.84–5.33	<0.001
None of the above	5 (0.2%)	8 (1.4%)	10 (1.1%)	27 (3.1%)	0.54	0.24–1.19	0.12	0.39	0.19–0.80	0.010

Risk ratios calculated adjusting for age as restricted cubic spline and non-Māori, non-Pacific ethnicity; 40 patients were of both Māori and Pacific ethnicity and appear in both columns.

CI, confidence interval; MNP, non-Māori, non-Pacific; RR, risk ratio.

admitted to the intensive care unit, and the proportion of hospitalised patients dying was reduced compared to NZ earlier in the pandemic[4,5] and contemporaneous international cohorts.[2,20,21] We did not identify any difference in mortality by ethnic group; however, our data showed differences in presentation and complications for Māori and Pacific peoples when compared to non-Māori, non-Pacific patients.

We found a substantially lower mortality (6.1%) and median length of hospital stay (2 days) than seen in the previous study during 2020 in NZ, where 12% of patients died in hospital and the median length of hospital stay was 4 days.[4] Similarly, the inpatient mortality of 3.5% observed in our study was lower than seen in Europe (10%) and the United States (13.1%) during a similar time period when the Omicron variant was prevalent.[21] While we did not identify a difference in mortality between ethnic groups, we highlight that our data included only those hospitalised and did not represent risk across the population. Existing work has indicated that at a population level, Māori and Pacific people experienced a higher mortality rate.[22] Possible explanations for the low inpatient mortality compared to the United States or Europe include differences in admission criteria, the high uptake of SARS-CoV-2 vaccination[14] and hospital bed pressure that may have been relatively lower.[23] It is notable that COVID-19 severity prediction scores developed early in the pandemic substantially overestimated the probability of death in our cohort, suggesting that variation in admission criteria is not sufficient to explain the difference.[16] We found that approximately one in five patients were readmitted within 28 days and that the risk of readmission did not vary by ethnicity. Further research is needed to determine risk factors for readmission and identify actions to reduce readmission rates to alleviate the associated burden on the individual, family and health system.

Although one in five admissions had pulmonary infiltrates on chest imaging, and one-quarter of patients were administered supplemental oxygen, severe pneumonitis or acute respiratory distress syndrome was an uncommon complication. These findings are in keeping with international cohorts, which found a lower prevalence of respiratory support in patients hospitalised due to infection by the Omicron variant of SARS-CoV-2 compared to previous variants.[2,24] We found an increased risk for respiratory-focused presentations for Māori and Pacific people when compared against non-Māori, non-Pacific people with increased prevalence of respiratory symptoms including cough, breathlessness and haemoptysis. There was also increased frequency of tachypnoea, hypoxia and pulmonary infiltrates on chest

Table 4 Admission observations and investigation findings of adults admitted to hospital due to COVID-19 by ethnicity, Aotearoa New Zealand, 2022

Characteristic	Descriptive				Māori compared to non-Māori, non-Pacific			Pacific compared to non-Māori, non-Pacific		
	Missing data, *n* (%)	Māori, *n* = 582	Pacific, *n* = 914	Non-Māori non-Pacific, *n* = 862	RR	95% CI	*P*-value	RR	95% CI	*P*-value
Symptom duration (days), median (Q1, Q3)	10 (0.4%)	3.0 (1.0, 6.0)	3.0 (1.0, 6.0)	3.0 (1.0, 6.0)	N/E			N/E		
Vital signs										
Tachycardia†	24 (1.0%)	167 (29.0%)	226 (25.0%)	222 (26.1%)	1.04	0.88–1.22	0.6	0.92	0.79–1.07	0.3
Tachypnoea‡	29 (1.3%)	57 (9.9%)	95 (10.5%)	51 (6.0%)	1.58	1.13–2.21	0.008	1.65	1.22–2.23	0.001
Hypotension§	87 (1.6%)	24 (4.2%)	21 (2.5%)	17 (2.0%)	2.37	1.32–4.26	0.004	1.19	0.66–2.15	0.6
Diastolic hypotension¶	103 (4.4%)	74 (13.1%)	100 (11.8%)	92 (11.0%)	1.36	1.02–1.80	0.035	1.13	0.88–1.47	0.3
Hypoxia††	29 (1.3%)	101 (17.6%)	187 (20.8%)	108 (12.7%)	1.49	1.18–1.89	<0.001	1.64	1.34–2.01	<0.001
Febrile‡‡	54 (2.3%)	118 (20.8%)	144 (16.1%)	120 (14.3%)	1.42	1.13–1.77	0.002	1.08	0.87–1.33	0.5
Radiology										
No chest imaging	4 (1.7%)	100 (17.2%)	90 (9.9%)	135 (15.7%)	1.01	0.97–1.04	0.7	1.05	1.03–1.08	<0.001
Chest X-ray	—	476 (81.8%)	818 (89.5%)	723 (83.9%)						
Chest CT scan	—	24 (4.1%)	44 (4.8%)	50 (5.8%)						
Total chest X-ray or CT scan	—	481 (82.8%)	821 (90.1%)	726 (84.3%)	1.01	0.97–1.04	0.7	1.05	1.03–1.08	<0.001
Pulmonary infiltrates ≥1 quadrant	—	75 (15.6%)	233 (28.4%)	110 (12.8%)	1.06	0.82–1.37	0.7	1.95	1.60–2.36	<0.001
Pulmonary infiltrates 2–3 quadrants	—	33 (6.9%)	118 (14.4%)	51 (7.0%)	1.00	0.66–1.51	>0.9	2.23	1.64–3.02	<0.001
Pulmonary infiltrates 4 quadrants	—	13 (2.7%)	41 (5.0%)	17 (2.3%)	0.90	0.46–1.77	0.8	1.86	1.10–3.13	0.020

Risk ratios calculated adjusting for age as restricted cubic spline, and non-Māori, non-Pacific ethnicity. Forty patients were of both Māori and Pacific ethnicity and appear in both columns.

†Tachycardia defined as heart rate ≥100 beats per minute.

‡Tachypnoea defined as respiratory rate ≥30 breaths per minute.

§Hypotension defined as systolic blood pressure ≤90 mmHg.

¶Diastolic hypotension was defined as diastolic blood pressure ≤ 60 mmHg.

††Hypoxia was defined as SpO_2 < 92% on room air or the initial reading taken on supplementary oxygen.

‡‡Febrile was defined as temperature ≥38°C.

CI, confidence intervals; CT, computed tomography; N/E, not estimated; RR, risk ratio.

radiograph. Physician diagnoses of respiratory complications including bacterial pneumonia and acute respiratory distress syndrome were more common for Pacific people and Māori respectively. We found non-respiratory complications were also common among all ethnic groups in the study, with more than one third of patients experiencing a complication of COVID-19. We found important differences by ethnicity, with acute kidney injury most commonly seen in Pacific peoples and Māori; likely influenced by the higher prevalence of chronic kidney disease and diabetes. Cardiac arrhythmia and shock were more commonly seen in Māori, which may be partially explained by the high proportion of Māori included in our study with underlying cardiovascular disease.

Current evidence and guidelines for patient monitoring and specific COVID-19 treatments in NZ and internationally have focussed on respiratory markers and complications.[25–27] While our data indicate that respiratory symptoms and complications remain important, COVID-19 is a multisystem disease and our findings emphasise the importance of a holistic and equity-centred approach to assessing and monitoring patients with COVID-19. Our findings underscore the importance of understanding the differential distribution of underlying comorbidities by ethnicity, population age structures and determinants of health as well as differences in quality of care[10,28,29] to support culturally safe and equitable public health responses and treatment pathways.

We saw variations in treatment by ethnicity, but quality of care would need to be assessed within the context of clinical decision making. Variations likely reflect complex clinical decision-making and increased odds of receiving treatment broadly reflect risks of complications. For example, Māori were at greater risk of shock and therefore were more likely to receive inotropic or vasopressor medication.

Table 5 Use of therapeutics and key hospital resources in adults admitted to hospital due to COVID-19 by Māori, Pacific and non-Māori, non-Pacific, Aotearoa New Zealand, 2022

Therapeutic or resource	Descriptive				Māori compared to non-Māori, non-Pacific			Pacific compared to non-Māori, non-Pacific		
	Missing data, *n* (%)	Māori, *n* = 582	Pacific, *n* = 914	Non-Māori, non-Pacific, *n* = 862	RR	95% CI	*P*-value	RR	95% CI	*P*-value
Therapeutic medication prior to hospital admission										
COVID-19 therapeutic antibody therapy	—	2 (0.3%)	5 (0.5%)	7 (0.8%)	N/E			N/E		
Antiviral therapy	10 (0.4%)	19 (3.3.%)	26 (2.8%)	28 (3.2%)	N/E			N/E		
Therapeutic medication during hospital admission										
Anti-coagulation†	37 (1.6%)	271 (46.6%)	564 (61.7%)	444 (51.5%)	0.92	0.83–1.02	0.10	1.18	1.09–1.28	<0.001
Intravenous fluids	77 (3.3%)	264 (45.4%)	437 (47.8%)	427 (49.5%)	0.92	0.83–1.03	0.2	0.96	0.88–1.06	0.4
Systemic corticosteroid‡	85 (3.7%)	227 (29.0%)	392 (42.9%)	271 (31.4%)	1.33	1.16–1.51	<0.001	1.36	1.21–1.52	<0.001
Antibiotic therapy	27 (1.2%)	201 (34.5%)	308 (33.7%)	256 (29.7%)	1.32	1.14–1.53	<0.001	1.19	1.05–1.35	0.008
Oxygen therapy	46 (2.0%)	135 (23.2%)	277 (30.3%)	193 (22.4%)	1.14	0.95–1.37	0.2	1.34	1.16–1.56	<0.001
Antiviral therapy§	25 (1.1%)	90 (15.5%)	130 (14.2%)	81 (9.4%)	1.69	1.29–2.20	<0.001	1.49	1.16–1.90	0.002
Immune-modulator therapy¶	19 (0.8%)	34 (5.8%)	89 (9.7%)	41 (4.8%)	1.10	0.73–1.66	0.6	1.85	1.32–2.56	<0.001
Non-invasive ventilation††	56 (2.4%)	25 (4.3%)	62 (6.8%)	18 (2.1%)	1.44	0.86–2.43	0.2	2.55	1.63–3.98	<0.001
Inotropes/vasopressors	31 (1.3%)	16 (2.7%)	9 (1.0%)	5 (0.6%)	3.05	1.30–7.13	0.010	1.11	0.44–2.78	0.8
Invasive ventilation	33 (1.4%)	9 (1.5%)	8 (0.9%)	5 (0.6%)	1.81	0.68–4.86	0.2	1.12	0.41–3.05	0.8
Renal replacement therapy or dialysis‡‡	32 (1.4%)	4 (0.7%)	7 (0.8%)	0 (0.0%)	N/E			N/E		
COVID-19 therapeutic antibody therapy	28 (1.2%)	1 (0.2%)	7 (0.8%)	1 (0.1%)	N/E			N/E		
Extracorporeal membrane oxygenation	33 (1.4%)	2 (0.3%)	0 (0.0%)	0 (0.0%)	N/E			N/E		

Forty patients were of both Māori and Pacific ethnicity and appear in both columns.

†Either prophylactic or therapeutic dose.

‡Oral or intravenous corticosteroid.

§Remdesivir, nirmatrelvir, molnupiravir.

¶Tocilizumab or baricitinib.

††Either continuous positive airway pressure or bi-level positive airway pressure started due to the acute illness.

‡‡Renal replacement therapy started following COVID-19 illness.

NE, not estimated; CI, confidence interval; RR, risk ratio.

Table 6 Complications among adults admitted to hospital due to COVID-19 by Māori, Pacific and non-Māori, non-Pacific, Aotearoa New Zealand, 2022

Characteristic	Descriptive				Māori compared to non-Māori, non-Pacific			Pacific compared to non-Māori, non-Pacific		
	Missing data (% overall)	Maori, $n = 582$	Pacific, $n = 914$	Other, $n = 862$	RR	95% CI	*P*-value	RR	95% CI	*P*-value
Acute renal injury	10 (0.4%)	79 (14%)	159 (18%)	69 (8.0%)	1.87	1.42–2.46	<0.001	2.18	1.72, 2.77	<0.001
Bacterial Pneumonia	27 (1.2%)	48 (8.3%)	99 (11%)	76 (8.9%)	1.11	0.79–1.56	0.5	1.32	1.00, 1.73	0.047
Delirium	38 (1.6%)	21 (3.7%)	58 (6.5%)	73 (8.6%)	0.78	0.49–1.23	0.3	1.00	0.73, 1.37	>0.9
Cardiac arrhythmia	12 (0.5%)	38 (6.5%)	53 (5.8%)	47 (5.5%)	1.60	1.07–2.41	0.023	1.20	0.83, 1.74	0.3
Shock	14 (0.6%)	19 (3.3%)	23 (2.5%)	11 (1.3%)	2.64	1.35–5.20	0.005	1.87	0.98, 3.55	0.057
Liver dysfunction	8 (0.3%)	11 (1.9%)	27 (3.0%)	21 (2.4%)	0.80	0.39–1.63	0.5	1.26	0.73, 2.19	0.4
Arterial or venous thromboembolism	12 (0.5%)	11 (1.9%)	10 (1.1%)	28 (3.3%)	0.66	0.33–1.33	0.2	0.35	0.17, 0.72	0.004
Bacteraemia	27 (1.2%)	12 (2.1%)	16 (1.8%)	19 (2.2%)	0.98	0.49–2.00	>0.9	0.81	0.42, 1.53	0.5
Cardiac infarction	10 (0.4%)	13 (2.2%)	14 (1.5%)	12 (1.4%)	2.21	1.03–4.74	0.042	1.22	0.59, 2.55	0.6
Acute respiratory distress syndrome	13 (0.6%)	16 (2.8%)	18 (2.0%)	7 (0.8%)	2.81	1.30–6.05	0.008	2.00	0.95, 4.22	0.069
Cardiac arrest	10 (0.4%)	9 (1.5%)	10 (1.1%)	7 (0.8%)	2.68	1.02–7.05	0.046	1.50	0.60, 3.74	0.4
Myocarditis/pericarditis	15 (0.6%)	12 (2.1%)	5 (0.6%)	19 (2.2%)	0.84	0.41–1.72	0.6	0.23	0.09, 0.60	0.003
Shock										

Risk ratios calculated adjusting for age as restricted cubic spline and other ethnicity; 40 patients were of both Māori and Pacific ethnicity and appear in both columns.
CI, confidence interval; RR, risk ratio.

Receipt of COVID-19 vaccination is a potential reason for differences in presentation and complications in our cohort. The effects of inequitable COVID-19 vaccination coverage in NZ were evident in our data, with approximately one in five Māori and Pacific patients not vaccinated against COVID-19 compared to approximately one in seven non-Māori, non-Pacific patients. Our data are consistent with a recent report on COVID-19 mortality in NZ which found that one-quarter of the difference in COVID-19 mortality between Māori and non-Māori was due to vaccination inequity.[14]

Design features influenced the interpretation of our results. Firstly, we employed a retrospective study design, and data were incomplete for some variables. Although systematic, selection of every second NMNP patient may have introduced selection bias. Diagnoses recorded were those of the treating physicians and under-recording of complications or misclassification are possible. For example, some cases recorded as bacterial

Table 7 Outcomes of adults admitted to hospital due to COVID-19 by Māori, Pacific and non-Māori, non-Pacific, Aotearoa New Zealand, 2022

Outcome	Missing data (overall)	Māori	Pacific	Non-Māori non-Pacific
Number of admissions (%)	—	582 (25.1%)	914 (39.4%)	862 (37.2%)
Length of hospital stay (days), median (Q1, Q3)	—	2.0 (1.0, 4.0)	2.0 (1.0, 5.0)	2.0 (1.0, 5.0)
Admission to intensive care unit	—	32 (5.5%)	26 (2.8%)	22 (2.6%)
Died in hospital	25 (1.1%)	19 (3.3%)	36 (3.9%)	28 (3.2%)
Died within 28 days of admission	42 (1.8%)	23 (4.0%)	64 (7.0%)	56 (6.5%)
Readmitted within 28 days	42 (1.8%)	103 (17.7%)	165 (18.1%)	142 (16.5%)
Age-adjusted outcome rates†				
Admission to intensive care unit	—	5.5 (3.8, 7.8)	3.3 (2.2, 5.0)	2.9 (1.8, 4.5)
Died in hospital	25 (1.1%)	3.3 (2.0, 5.1)	3.3 (2.3, 4.8)	1.8 (1.1, 2.9)
Died within 28 days of admission	42 (1.8%)	4.0 (2.5, 5.9)	5.4 (4.1, 7.1)	3.5 (2.5, 5.0)
Readmitted within 28 days	42 (1.8%)	18.0 (14.7, 21.9)	17.4 (14.7, 20.6)	16.6 (13.7, 20.0)

Data presented rates (95% confidence intervals) per 100 patients directly age-standardised to match the age structure of the 582 Māori patients in the sample. Forty patients were of both Māori and Pacific ethnicity and appear in both columns.
†Age-adjusted outcome rates of adults (aged ≥16 years) admitted to hospital due to COVID-19, by Māori, Pacific, non-Māori non-Pacific and total population, Aotearoa New Zealand, 2022.

pneumonia may have had viral pneumonitis. There is potential for misclassification of ethnicity, as we did not confirm the ethnicity recorded in health records directly with patients. Under-recording of Māori and Pacific peoples in health records has been documented elsewhere.[11,30] We attempted to mitigate this through reporting of 'total' ethnicity which allowed an individual to be classified as both of Māori and Pacific peoples; use of multiple administrative data sources; and an 'ever Māori' or 'ever Pacific person' approach. Finally, our study population included only patients admitted to hospitals with a preponderance of hospitals in larger population centres and our findings may be less applicable to patients attending hospitals in rural areas or in primary care.

Our study underscores that COVID-19 has become a multisystem illness with diverse complications. Key patient outcomes including mortality did not vary by ethnic group in our cohort of hospitalised patients. However, clinical presentations and complications varied between ethnic groups, which likely reflect the differential distribution of comorbidities, COVID-19 risk and protective factors in the population and access to social determinants of health, including healthcare. This highlights the necessity of effective and equitable healthcare and public health responses, which recognise current health inequities experienced by Māori and Pacific peoples in NZ, for both future waves of COVID-19 and subsequent infectious disease epidemics.

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Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's web-site:

Appendix S1. Supporting Information.
Appendix S2. Supporting Information.