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Original Research

Ethnic equity in Aotearoa New Zealand's COVID-19 response: A descriptive epidemiological study

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ABSTRACT

Objectives: Aotearoa New Zealand employed one of the most stringent public health pandemic responses internationally. We investigated whether ethnic health equity was achieved in the response and outcomes, from COVID-19 elimination in June 2020 through to Omicron-response easing, including international border reopening, in 2022.
Study design: Descriptive epidemiology study.
Methods: All COVID-19 cases, patients tested for SARS-CoV-2 and people vaccinated against COVID-19 between 9 June 2020 and 13 April 2022 were examined over three response periods: by demographic features and COVID-19 outcomes, transmission and vaccination patterns, time-to-vaccination and testing rates.
Results: There were 15,693 cases per 100,000, 138·7 hospitalisations per 100,000, and 9·8 deaths per 100,000 people. Pacific peoples and Indigenous Māori had, respectively, 9·3 to 35-fold and 1·5 to 8·3-fold higher risk of COVID-19, 5·1-fold and 2·6-fold higher age-standardised risk of hospitalisation and 9-fold and 4-fold higher age-standardised risk of death, than European or Other. Māori and Pacific peoples had lower vaccination coverage at critical points in the response, and slower access to vaccination (Adjusted Time Ratios for two doses 1·32 (95% CI 1·31–1·32) and 1·14 (1·14–1·14), respectively), than European or Other. Testing rates remained high, especially among Māori and Pacific peoples.
Conclusions: Despite achieving a low overall burden of disease by international comparisons, the multi-faceted New Zealand response did not prevent stark ethnic inequities in access to vaccination and COVID-19 outcomes. Policies which address disparities in upstream determinants, early vaccine programme planning and implementation with high-risk communities, and prioritisation that addresses systematic ethnic disadvantage and promotes health equity in response decisions is recommended.

1. Introduction

Indigenous and other minoritised ethnic groups have been disproportionately impacted by the COVID-19 pandemic in many countries.[1] Aotearoa New Zealand's initial stringent COVID-19 response was notable internationally for the resulting low burden of disease and relatively few disparities during the first wave.[2] However, some health inequities were identified. 'Healthy travellers' imported disease which spread to vulnerable communities who experienced more severe outcomes, particularly older, and Pacific and Asian peoples.

Border closures, lockdown, intensive case and contact management, surveillance enhancements, and social supports eliminated COVID-19 by June 2020. Thereafter, New Zealand adapted the response, introducing geographically-targeted lockdowns, mandatory masking and

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vaccination. Progressive easing of interventions then culminated in complete border re-opening in mid-2022.

New Zealand's COVID-19 response aimed to achieve health equity.[3,4] In previous epidemics and pandemics, Indigenous Māori and Pacific peoples were disproportionately and severely affected.[5] These inequities stem from the social determinants of health, long-term impacts of colonisation, intergenerational poverty and systemic racism, and for Māori, breaches of Te Tiriti o Waitangi (the Treaty of Waitangi 1840, between Māori and the British Crown).[6]

The Government committed to fulfilling Treaty obligations; upholding principles of Māori self-determination, partnership (Māori co-design and delivery), options (by Māori for Māori), active protection (of Māori rights), and equity (in response design, delivery and outcomes).[4] It also invested in Pacific peoples COVID-19 recovery.[7] However, Māori leaders questioned whether vaccine prioritisation addressed Māori equity and whether Māori were equitably protected when restrictions were eased.[8] Similarly, Pacific peoples leaders advocated for Pacific-tailored responses to protect diverse communities and prevent ongoing disparities.[9]

To inform future pandemic approaches we investigated whether New Zealand's COVID-19 response achieved health equity after the first pandemic wave, despite anticipated social, economic and political pressures,[10] and changing disease dynamics.

2. Methods

2.1. Study population and periods

We examined all confirmed and probable COVID-19 cases, all people tested for SARS-CoV-2 and all people receiving COVID-19 vaccination in New Zealand between 9 June 2020 (Alert Level 1 following COVID-19 elimination[11]) and 13 April 2022 (including the most restrictive Omicron-wave response) – Panel S1. Ethnic equity of COVID-19 outcomes and access to response measures were considered in three response periods covering major variant community outbreaks. Fig. 1 summarises case trends and COVID-19 control measures. Fig. 2 summarises vaccination eligibility stages.

Period 1 (9 June 2020 to 17 August 2021): COVID-19 elimination was maintained with border closure and Alert Level adjustments[11] including for a B.1.1.1-variant outbreak in Auckland. Staged eligibility for free COVID-19 vaccination (Pfizer/BioNTech) was implemented from 20 February, initially targeting frontline workers, older and comorbid groups, and their households, with sequenced age-based eligibility from 28 July.

Period 2 (18 August 2021 to 23 January 2022): National Alert Level 4 lockdown was introduced for the Delta-outbreak, with de-escalation to Alert Level 2 by 8 September, except for the Auckland epicentre where stricter restrictions continued until progressive easing commenced from 22 September. 16 October was a national vaccination promotion day ('vaxathon'). On 29 November, booster vaccinations commenced for

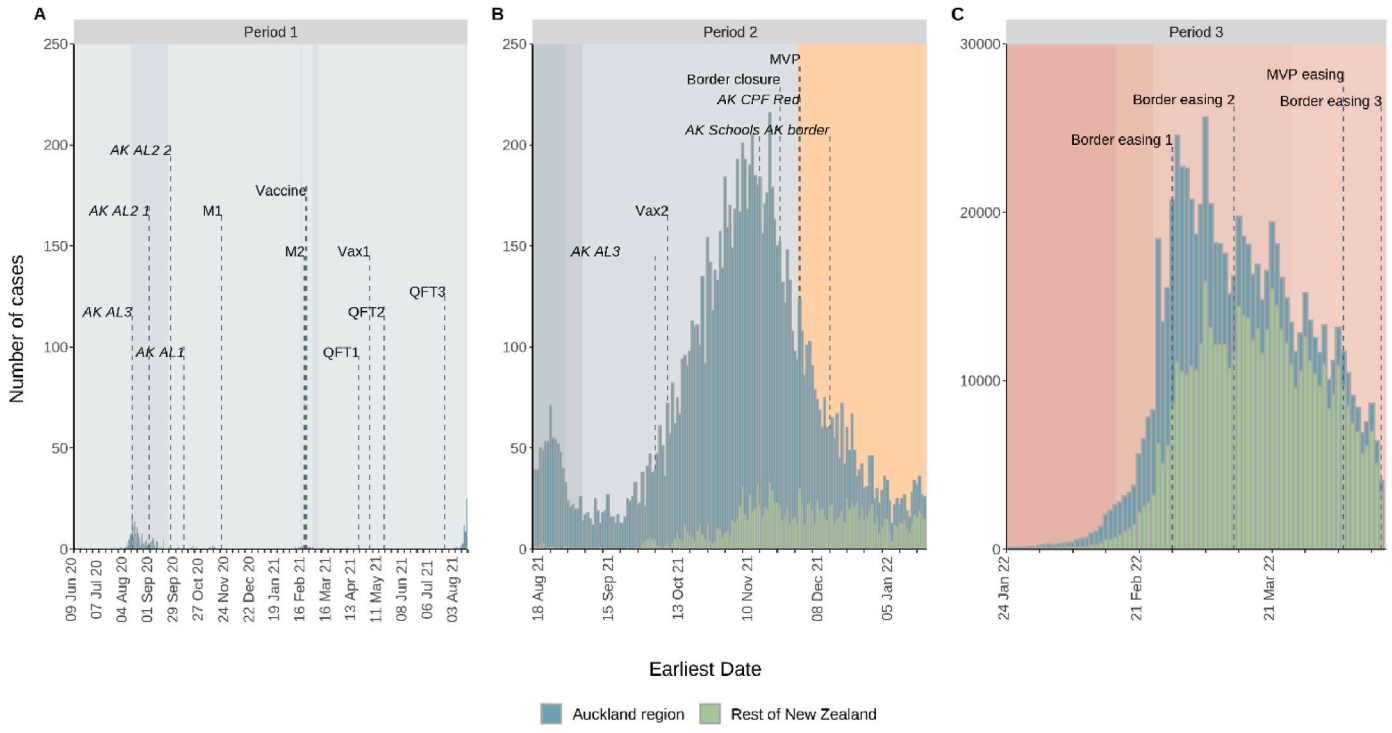

Fig. 1. Key features of the COVID-19 epidemic and response timeline by response period
Legend: Grey-scale indicates Alert Levels (AL): 1 (light grey) to 4 (dark grey); Coloured background shows COVID-19 Protection Framework (CPF) Orange and Red Omicron phases. Variations in Auckland (*AK*) are flagged. M = Masks are mandatory on 1) airplanes and Auckland public transport, 2) all public transport; Vaccine = COVID-19 vaccinations commence; Quarantine-free travel with Australia (QFT1) and some Pacific Islands (QFT2) introduced (and paused = QFT3); Mandatory vaccination for border workers (Vax1) and frontline workers (Vax2); MVP = Digital vaccination certification commences; Border closure = Entry paused to New Zealanders travelling from southern African countries due to Omicron emergence; *AK AL3* = AL3 with further easing of restrictions, including opening of Early Childhood education followed by some public facilities with masks and distancing; *AK schools* = Schools open; *AK border* = Crossing of the Auckland regional border allowed if COVID-19 vaccinated or test negative; Border easing 1 = Vaccinated New Zealanders can self-quarantine; Border easing 2 = New Zealanders from the rest of the world and others with eligible temporary work visas can self-test without quarantine and self-isolate if positive; MVP easing = MVP optional for most settings but mandatory for healthcare and border workers; Border easing 3 = Fully vaccinated Australian citizens, some other visa-holders, students and critical workers can enter, self-test, and self-isolate if positive.

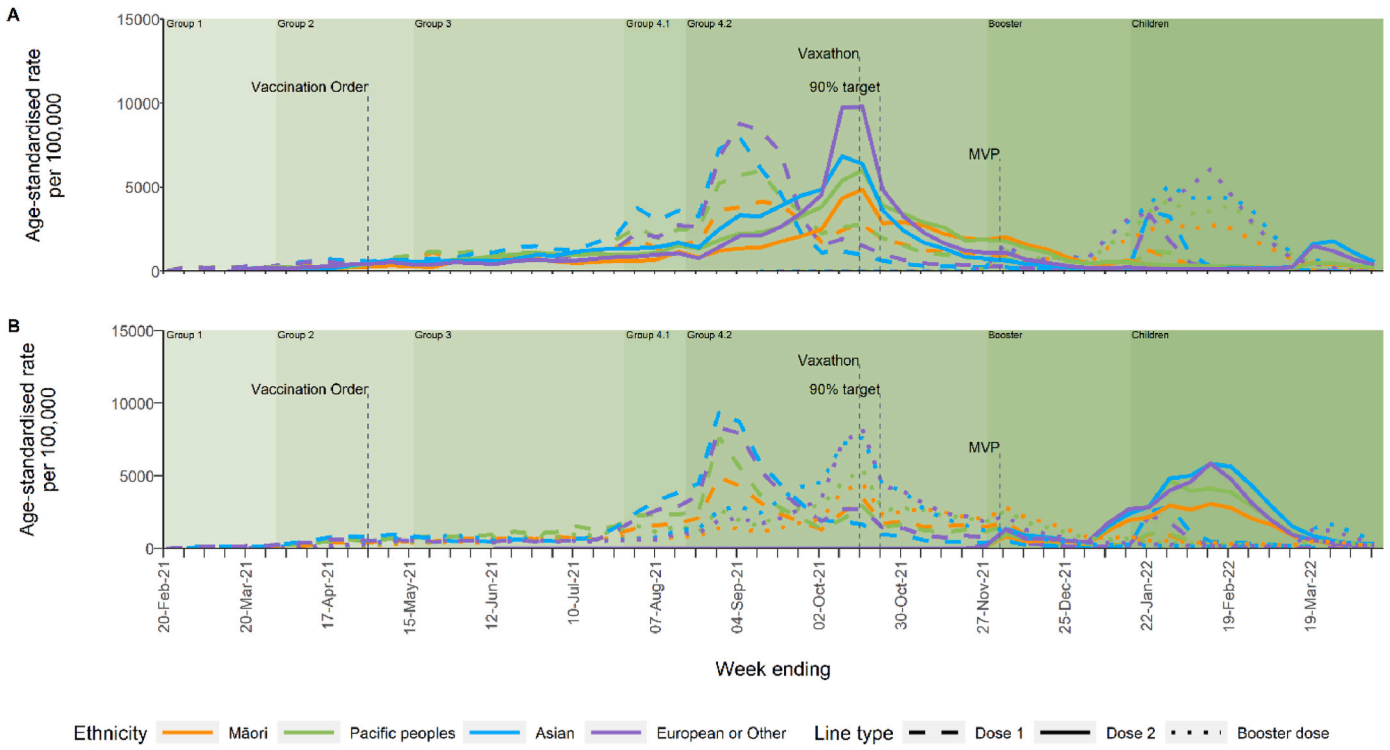

Fig. 2. Age-standardised rates of vaccination by ethnicity and COVID-19 vaccination eligibility groupings A) in the Auckland region, and B) the rest of New Zealand Legend: Vaccination eligibility: Group 1 = Border workers and household contacts; Group 2 = Frontline workers and higher-risk groups (long-term care residents, Māori and Pacific peoples ≥65 years or with specific comorbidities, and household contacts) or people living in Counties Manukau Auckland (having a high Border workforce) either ≥65 years or with comorbidities; Group 3 = all people aged ≥65 years, people with disabilities or comorbidities or pregnant; Group 4.1 = Sequenced age-based eligibility for ≥60 year olds (28 July), ≥55 year olds (11 August) and ≥50 year olds (13 August); Group 4.2 = ≥40 year olds (18 August), 12–15 year olds with eligible parents/caregivers (20 August), ≥30 year olds (25 August), and 16–29 year olds (1 September); Booster = Frontline healthcare workers, ≥65 year olds, Māori and Pacific aged ≥50 years, and peoples with comorbidities; Children = 5–11 year olds are eligible for primary course, and ≥18 year olds for booster. Vaccination Order = First required of border workers; 90% target = Regional 90% vaccination coverage target set by Government (rescinded 3 weeks later); MVP = My Vaccine Pass digital vaccination certification for mandatory settings.

higher-risk groups.

On 3 December, a 'minimise [healthcare burden] and protect [vulnerable peoples]' strategy was introduced using the COVID Protection Framework (CPF),[12] with Red-restrictions for Auckland and Orange elsewhere. Additionally, a secure Auckland regional border was maintained, with cross-border movement permitted from 15 December with proof of primary-dose vaccination, recent negative PCR or Rapid Antigen Test (RAT).

Period 3 (24 January to 13 April 2022): A phased Omicron-outbreak response occurred at CPF Red-restrictions: Phase 1 (24 January–16 February) aimed to eliminate Omicron. Social supports commenced for cases and close contacts isolating at home for 14 and 10 days, respectively; Phase 2 (16–24 February) aimed to slow spread. Seven-day self-quarantine was required for symptomatic people, with day 5 PCR testing. Cases self-isolated for 10 days; Phase 3 (25 February–25 March) prioritised protection of high-risk people. Positive RAT self-reporting was introduced, and self-contact tracing. Border re-opening commenced (Fig. 1); Phase 4 (26 March–13 April) introduced further easing. Restrictions on gatherings eased. On 5 April, mandatory vaccination eased for most workplaces and venues. On 14 April, New Zealand moved to CPF Orange-restrictions with increased easing.

2.2. Data sources

Case data were extracted on 13 June 2022 from EpiSurv, the national notifiable diseases database, and the National Contact Tracing Solution database, including: age, sex, location, NZDep2018 quintile[13] (1 least to 5 most socio-economically deprived), infection source (imported or community variant-outbreak), and earliest date (symptom onset or notification date). Dates of death and hospitalisation (COVID-19 underlying causes), and Morbidity-3 (M3) hospital-identified co-morbidity scores based on hospital admissions (including 61 ICD-10 coded chronic conditions in the National Minimum Data Set)[14,15] in the 5 years to 30 June 2021 and 31 December 2021, were linked to Delta and Omicron cases, respectively, by the Ministry of Health using the National Health Index (NHI) patient identifier.

Ethnicity was NHI-linked and grouped using total response classification whereby individuals identifying as Māori, Pacific peoples and Asian ethnicities were counted in as many of these groups as they identified.[16] All others were assigned to a residual non-overlapping European or Other reference group (non-Māori, non-Pacific, non-Asian).

Data on all COVID-19 vaccinations delivered were extracted from the COVID Vaccination Registry on 20 January 2023, including vaccine type, delivery date and recipient metadata: age, sex, NHI-linked ethnicity, location, NZDep2018. Results of all SARS-CoV-2 tests were extracted on 7 October 2022 from Éclair, the SARS-CoV-2 test results repository, with metadata.

2.3. Outcome measures

Burden of disease comparisons examined case counts and severe outcomes, cumulative incidence, relative risks, by demographics, infection source, number of vaccine doses, and response period. For period 3, case data were examined to 24 February and separately to 13 April for potential RAT self-reporting bias.

Ethnic differences in rates of testing, age-standardised vaccination, vaccine coverage (the proportion of eligible populations vaccinated with at least two or three doses more than 7 days before key response change

points - 22 September and 3 December easing, and 24 January Omicron response) and time-to-vaccination with second and booster doses were compared relative to response periods. Due to major regional response differences, analyses were stratified by the Auckland region (Auckland, Waitematā and Counties Manukau districts) and the rest of New Zealand.

2.4. Statistical analyses

Rates and proportions were calculated with 95% Confidence Intervals (CI) assuming Poisson and Binomial distributions, respectively. Annual Stats NZ population estimates applying Census 2018 total ethnicity and NZDep2018 population proportions were used in denominators. New Zealand's 2021 estimated 5.1M population were grouped into approximately 17% Māori, 9% Pacific peoples, 16% Asian, and non-overlapping 61% European or Other group. Hospitalisation, mortality and vaccination rates were age-standardised to the 2018 Māori population to remove confounding by the older European-predominant New Zealand age structure. The Stats NZ population dataset was chosen for better representing Māori, and as distinct from the national reporting of statistics by the Ministry of Health during the pandemic which used Health Service User (HSU) population datasets. HSU datasets have not been well validated against Census-derived estimates, are expected to misclassify and undercount Māori and count non-residents, and are not recommended for time-series analyses.[17,18]

Risk factors for severe outcomes among cases were examined using logistic regression to estimate odds ratios (OR) and 95% CIs. Crude ORs were calculated for age and sex. Due to confounding by age, all other ORs were at least age-sex adjusted. Sequential multivariable adjustments were then applied to examine the associations of vaccination status, socio-economic deprivation and comorbidities with ethnic differences in severe outcomes.

Accelerated failure time (AFT) models estimated time-to-second dose and booster vaccination among those who received two doses, using time ratios (TR). To assess model fit, AIC and BIC values were compared for AFT models using various distributions, and residuals were inspected. The AFT model specifying a Weibull distribution was the best fit. Cox regression was not used due to a violation of the proportionality assumption. The start time was age-sequenced eligibility for second dose or time from second dose, respectively. Those prioritised to receive vaccination prior to age-sequencing were not included but described. Multivariable models sequentially adjusted for age group, NZDep2018, COVID-19 infection pre-vaccination, and whether an individual was eligible for booster vaccinations prior to booster availability.

R (4.0.3 and 4.1.2) was used for statistical calculations.

3. Results

792,458 confirmed and 11,420 probable COVID-19 cases (15,693 cases per 100,000) and 504 COVID-19 related deaths (9·8 deaths per 100,000) were notified during the study period. Imported cases were predominantly male, young adults, of lower socio-economic deprivation, and European or Other, or Asian ethnicity (Table 1). Community cases were predominantly young adults and school-aged children, of higher socio-economic deprivation, and Pacific peoples or Māori in most periods. Across the B.1.1.1, Delta, and most stringent Omicron response, COVID-19 incidence was approximately 9·3 to 35-fold higher for Pacific peoples, 1·5 to 8·3-fold higher for Māori, and 1·4 to 2·1-fold higher for Asians than European or Other. Following RAT self-reporting, Omicron cases were predominantly female, European or Other, with a less marked social gradient.

Superspreading events in Auckland initiated three major outbreaks. The B.1.1.1 outbreak affected Auckland-based Pacific border workers and church groups. In the first two weeks of the Delta-wave, 74% (514/692) of cases were Pacific peoples (involving a Pacific communities' church in Auckland), 10% were European or Other, 9·8% Asian, and 6% Māori. The Omicron outbreak commenced at an Auckland-based wedding. Initially, 45% (874/1936) of cases were Asian, 24% Pacific peoples, 19% European or other, and 11% Māori.

Pacific peoples and Māori had the highest weekly age-standardised hospitalisation rates (Fig. 3) and higher overall and variant-specific cumulative age-standardised hospitalisation and mortality rates (Table S1). Māori and Pacific peoples had higher age-sex adjusted odds of hospitalisation during Delta and Omicron waves (1·26 (1·03-1·54) and 1·45 (1·19-1·78), respectively, for Delta, and 1·84 (1·72-1·96) and 2·22 (2·08-2·37), respectively, for Omicron) than European or Other (Table S2). Applying further sequential multivariable adjustments (Table S3), under-vaccination was associated with approximately 25% and 14% higher Omicron hospitalisation risk and 25% and 49% higher Omicron mortality risk affecting Māori and Pacific peoples, respectively, relative to European or Other. Socio-economic deprivation was then associated with approximately 12% higher Delta hospitalisation risk for Pacific peoples, and respectively, 22% and 22% higher adjusted Omicron mortality risk for Māori and Pacific peoples, compared with European or Other. Hospital-documented comorbidities were further associated with approximately 28% and 20% higher Omicron mortality risk, respectively, for Māori and Pacific peoples relative to European or Other. Following multivariable analyses, Pacific peoples had 34% higher risk of hospitalisation during the Delta-wave (aOR 1·34 (1·06-1·69)). Risk of hospitalisation was higher for both Māori and Pacific peoples during the Omicron-wave (aOR 1·20 (1·12-1·29) and 1·50 (1·39-1·62), respectively, versus European or Other).

All three B.1.1.1-related deaths were among Māori and Pacific peoples, and 44% of Delta-related deaths were Māori, 22% Pacific peoples, 22% European or Other, and 17% Asian (Table S2). Māori and Pacific peoples had 80–98% higher risk of Omicron-related mortality than European or Other, after age-sex adjustment which reduced after adjustment for potentially modifiable risk factors (Table S3). Māori and Pacific peoples with Omicron-related deaths were younger (81% and 53%, respectively, were <80 years old versus 30% European or Other), less likely to be fully vaccinated, and more likely to be living in areas of higher socio-economic deprivation compared to European or Other.

During the study period, 11·1M doses of COVID-19 vaccine were delivered to 4,326,636 people (84% of the population). 17% of the population received two-dose vaccination prior to the age-sequenced rollout. They were predominantly European or Other and Asian, female, young adults, and less socio-economically deprived (Table S4). Fig. 2 shows ethnic differences in age-standardised vaccination rates over time by dose, with European or Other and Asian people having the highest rates for each dose, and Pacific peoples then Māori the lowest. Weekly two-dose vaccination peaked for all ethnic groups around the vaxathon.

When Delta-response restrictions were first eased in Auckland, national two-dose vaccine coverage was 20% for Māori, 29% for Pacific peoples compared with 37% for European or Other (Table 2). Disparities persisted at CPF easing, with 57% of eligible Māori and 77% of eligible Pacific peoples having two-dose coverage compared with 83% of European or Other. Disparities persisted for booster coverage (9·7% and 11% for Māori and Pacific peoples, respectively, versus 22% for European or Other). From age-sequenced eligibility, time-to-two dose and booster vaccination was, respectively, 32% and 8% longer for Māori, and 14% and 11% longer for Pacific peoples, than European or Other (Table S5). These differences were more pronounced in Auckland compared to the rest of New Zealand.

Rates of testing were highest for Māori and Pacific peoples during all response periods (Fig. S1). Test positivity remained <5% for all ethnic groups despite high rates of testing until the introduction of positive RAT self-reporting (Fig. S2).

4. Discussion

New Zealand's response to COVID-19 through the first two years of

Table 1
Demographic characteristics of community COVID-19 cases during response periods, and imported cases during the study period.

DEMOGRAPHICS	Period 1: B.1.1.1 outbreak			Period 2: Delta outbreak			Period 3[b] phases 1 and 2: Omicron outbreak		
	Cases (%)	Incidence risk per 100,000 (95% CI)	Relative risk (95% CI)	Cases (%)	Incidence risk per 100,000 (95% CI)	Relative risk (95% CI)	Cases (%)	Incidence risk per 100,000 (95% CI)	Relative risk (95% CI)
Ethnic group									
Māori	42 (22)	4·7 (3·4–6·4)	6·46 (3·88–10·73)	5210 (42)	586·8 (571·0–602·9)	8·31 (7·90–8·73)	4350 (13)	489·9 (475·5–504·7)	1·55 (1·49 - 1·60)
Pacific peoples	114 (61)	25·7 (21·2–30·9)	35·09 (22·42–54·91)	4053 (33)	914·1 (886·3–942·6)	12·94 (12·29–13·63)	13104 (40)	2955·5 (2905·8–3005·7)	9·34 (9·10 - 9·58)
Asian	9 (4·8)	1·1 (0·5–2·0)	1·47 (0·68–3·17)	806 (7·0)	96·2 (89·7–103·0)	1·36 (1·26–1·48)	5489 (17)	655·0 (637·8–672·5)	2·07 (2·00 - 2·14)
European or Other	23 (12)	0·7 (0·5–1·1)	Ref	2217 (18)	70·6 (67·7–73·6)	Ref	9934 (30)	316·5 (310·3–322·8)	Ref
Unknown	0	..	..	38 (0·0)	..	..	183 (1·0)	..	..
Total[a]	188	..	..	12324	..	..	33060	..	..
Sex									
Male	85 (47)	3·4 (2·7–4·1)	Ref	5736 (50)	226·1 (220·3–232·0)	Ref	15739 (49)	620·4 (610·7–630·1)	Ref
Female	94 (53)	3·7 (3·0–4·5)	1·09 (0·81–1·46)	5716 (50)	222·0 (216·3–227·9)	0·98 (0·95–1·02)	16109 (50)	625·8 (616·2–635·5)	1·01 (0·99 - 1·03)
Unknown	0	..	..	25 (0·2)	..	..	78 (0·2)	..	..
Age group (years)									
<1	2 (1·1)	3·3 (0·4–11·8)	0·85 (0·20–3·49)	235 (2)	385·0 (337·5–437·4)	1·21 (1·06–1·38)	246 (1·0)	403·1 (354·4–456·6)	0·38 (0·34 - 0·44)
1–4	7 (3·9)	2·9 (1·2–5·9)	0·74 (0·33–1·65)	896 (8·0)	367·0 (343·4–391·8)	1·15 (1·07–1·24)	1000 (3·0)	409·6 (384·7–435·8)	0·39 (0·37 - 0·42)
5–19	52 (29)	5·3 (4·0–7·0)	1·37 (0·91–2·06)	3129 (27)	320·3 (309·2–331·7)	1·00 (0·96–1·05)	9708 (30)	993·7 (974·1–1013·6)	0.95 (0·92 - 0·97)
20–34	42 (23)	3·9 (2·8–5·2)	Ref	3458 (30)	319·0 (308·5–329·8)	Ref	11389 (36)	1050·6 (1031·5–1070·0)	Ref
35–49	39 (22)	4·0 (2·8–5·5)	1·03 (0·67–1·59)	2114 (18)	216·5 (207·4–226.0)	0·68 (0·64–0·72)	5586 (17)	572·2 (557·3–587·3)	0·54 (0·53 - 0·56)
50–64	29 (16)	3·0 (2·0–4·4)	0·79 (0·49–1·26)	1233 (11)	129·6 (122·4–137.0)	0·41 (0·38–0·43)	2968 (9·0)	311·9 (300·8–323·3)	0·30 (0·29 - 0·31)
65–79	7 (3·9)	1·1 (0·5–2·3)	0·29 (0·13–0·65)	339 (3·0)	54·4 (48·8–60·5)	0·17 (0·15–0·19)	838 (3·0)	134·6 (125·6–144·0)	0·13 (0·12 - 0·14)
≥80	1 (0·6)	0·5 (0·0–2·9)	0·13 (0·02–0·96)	73 (1·0)	37·5 (29·4–47·2)	0·12 (0·09–0·15)	170 (1·0)	87·3 (74·7–101·5)	0·08 (0·07 - 0·10)
Unknown	0	..	..	0	..	..	21 (0·0)	..	..
NZDep[c] quintile									
1 (least deprived)	12 (7·0)	1·2 (0·6–2·1)	Ref	632 (6·0)	64·8 (59·8–70·0)	Ref	3308 (10)	339·1 (327·6–350·8)	Ref
2	8 (4·5)	0·8 (0·3–1·6)	0·65 (0·27–1·60)	1025 (9·0)	103·1 (96·9–109·6)	1·59 (1·44–1·76)	4022 (13)	404·7 (392·3–417·3)	1·19 (1·14 - 1·25)
3	19 (11)	1·9 (1·1–2·9)	1·53 (0·74–3·14)	1312 (11)	129·6 (122·6–136·8)	2·00 (1·82–2·20)	4694 (15)	463·5 (450·4–476·9)	1·37 (1·31 - 1·43)
4	57 (32)	5·5 (4·1–7·1)	4·45 (2·39–8·29)	2214 (19)	212·4 (203·7–221·4)	3·28 (3·00–3·58)	6773 (21)	649·8 (634·5–665·4)	1·92 (1·84 – 2·00)
5 (most deprived)	80 (45)	7·4 (5·8–9·2)	5·98 (3·26–10·98)	6058 (53)	557·4 (543·5–571·6)	8·60 (7·93–9·34)	12581 (39)	1157·6 (1137·5–1177·8)	3·41 (3·29 - 3·55)
Unknown	3 (1·7)	..	..	236 (2·0)	..	..	548 (2·0)	..	..
Total	179	..	..	11477	..	..	31926	..	..

DEMOGRAPHICS	Period 3[b] phases 3 and 4: Omicron outbreak			Imported		
	Cases (%)	Incidence risk per 100,000 (95% CI)	Relative risk (95% CI)	Cases (%)	Incidence risk per 100,000 (95% CI)	Relative risk (95% CI)
Ethnic group						
Māori	154460 (20)	17397·0 (17318·2–17476·0)	1·36 (1·35–1·37)	228 (5·0)	25·7 (22·5–29·2)	0·4 (0·3–0·4)
Pacific peoples	106740 (14)	24073·9 (23948·2–24200·1)	1·88 (1·87–1·89)	279 (6·0)	62·9 (55·8–70·8)	0·9 (0·8–1·1)
Asian	106924 (14)	12758·5 (12687·1–12830·1)	1·00 (0·99–1·00)	1454 (32)	173·5 (164·7–182·6)	2·6 (2·4–2·8)
European or Other	401417 (52)	12789·9 (12753·0–12826·9)	Ref	2112 (46)	67·3 (64·5–70·2)	Ref
Unknown	4458 (1·0)	..	..	514 (11)	..	..
Total[a]	773999	..	..	4587	..	..
Sex						
Male	355462 (47)	14010·8 (13968·1–14053·6)	Ref	2418 (53)	95·3 (91·5–99·2)	Ref

(*continued on next page*)

Table 1 (*continued*)

DEMOGRAPHICS	Period 3[b] phases 3 and 4: Omicron outbreak			Imported		
	Cases (%)	Incidence risk per 100,000 (95% CI)	Relative risk (95% CI)	Cases (%)	Incidence risk per 100,000 (95% CI)	Relative risk (95% CI)
Female	399505 (53)	15518·9 (15474·7–15563·2)	1·11 (1·10–1·11)	2119 (47)	82·3 (78·8–85·9)	0·9 (0·8–0·9)
Unknown	782 (0·1)	..	..	10 (0·0)	..	..
Age group (years)						
<1	6016 (1·0)	9857·1 (9621·7–10096·3)	0·49 (0·48–0·50)	54 (1.2)	88·5 (66·5–115·4)	0.6 (0·5–0·8)
1–4	30830 (4·0)	12628·6 (12497·1–12761·0)	0·62 (0·62–0·63)	204 (4·5)	83.6 (72·5–95·8)	0.6 (0·5–0·7)
5–19	200294 (27)	20502·0 (20422·0–20582·2)	1·01 (1·01–1·02)	581 (13)	59·5 (54·7–64·5)	0·4 (0·4–0·5)
20–34	219407 (29)	20240·5 (20164·9–20316·3)	Ref	1569 (35)	144·7 (137·7–152·1)	Ref
35–49	170789 (23)	17493·7 (17418·4–17569·2)	0·86 (0·86–0·87)	1170 (26)	119·8 (113·1–126·9)	0·8 (0·8–0·9)
50–64	91693 (12)	9636·1 (9576·9–9695·5)	0·48 (0·47–0·48)	750 (16)	78·8 (73·3–84·7)	0·5 (0·5–0·6)
65–79	29807 (4·0)	4786·0 (4733·1–4839·3)	0·24 (0·23–0·24)	212 (4.7)	34·0 (29·6–38·9)	0·2 (0·2–0·3)
≥80	6892 (1·0)	3540·9 (3459·2–3624·0)	0·17 (0·17–0·18)	7 (0.2)	3·6 (1·4–7·4)	0·0 (0·0–0·1)
Unknown	21 (0·0)	..	..	0	..	..
NZDep[c] quintile						
1 (least deprivation)	130550 (17)	13380·9 (13313·4–13448·6)	Ref	953 (21)	97·7 (91·6–104·1)	Ref
2	128023 (17)	12880·8 (12815·0–12946·9)	0·96 (0·96–0·97)	825 (18)	83·0 (77·4–88·9)	0·8 (0·8–0·9)
3	137538 (18)	13581·6 (13514·9–13648·4)	1·01 (1·01–1·02)	837 (18)	82·7 (77·1–88·4)	0·8 (0·8–0·9)
4	154418 (20)	14815·0 (14746·8–14883·3)	1·11 (1·10–1·11)	801 (18)	76·8 (71·6–82·4)	0·8 (0·7–0·9)
5 (most deprivation)	192127 (25)	17677·3 (17605·6–17749·2)	1·32 (1·31–1·33)	658 (14)	60·5 (56·0–65·3)	0·6 (0·6–0·7)
Unknown	13093 (2·0)	..	..	473 (10)	..	..
Total	755749	..	..	4547	..	..

[a] Counts exceed case total due to representation by total response ethnicity classification for Māori, Pacific peoples and Asian ethnic groups. European or Other reference group represents non-Māori, non-Pacific, non-Asian identifying people.

[b] Period 3 stratified by phases 1–2 (24 January to 24 February 2022) and phases 3–4 (25 February to 13 April 2022) due to introduction of Rapid Antigen Test (RAT) self-reporting on 25 February 2022.

[c] New Zealand index of socio-economic deprivation 2018.

Fig. 3. Age-standardised rates of hospitalisation during response periods 2 and 3, by ethnicity, A) Auckland region, and B) Rest of New Zealand
Legend: Age-standardised rates are presented per 100,000 with 95% CIs shown as shading. Grey background represents Alert Levels 1 (light grey) to 4 (dark grey). Orange and red background represents the COVID-19 Protection Framework (CPF) traffic light settings Orange, and Red (darkest to lightest indicate Omicron phases 1–4). Response period 1 is not presented due to small numbers.

Table 2
Vaccine coverage by ethnic group at key response change points.

Characteristic	Māori	Pacific peoples	Asian	European or Other
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
Two dose immunity by 22 September 2021 (Delta response eased in Auckland region)[a]				
All New Zealand	20 (20–20)	29 (29–30)	36 (36–37)	37 (37–37)
- Auckland region	20 (20–20)	30 (30–30)	40 (40–40)	36 (36–36)
- Rest of New Zealand	19 (19–19)	26 (26–26)	30 (29–30)	36 (36–36)
Two dose immunity by 3 December 2021 (CPF introduced)[a]				
All New Zealand	57 (57–58)	77 (76–77)	87 (87–87)	83 (83–83)
- Auckland region	59 (58–59)	79 (78–79)	86 (86–86)	85 (84–85)
- Rest of New Zealand	55 (55–55)	69 (68–69)	86 (85–86)	81 (81–81)
Booster immunity by 24 January (start of Omicron Response)[b]				
All New Zealand	9·7 (9·6–9·8)	11 (11–11)	14 (14–13)	22 (22–22)
- Auckland region	10 (10–10)	11 (11–12)	15 (15–15)	23 (23–23)
- Rest of New Zealand	9·1 (9.0–9·2)	9·4 (9·3–9·6)	12 (11–12)	21 (21–21)

[a] Eligibility defined as those aged 12 years and over and received all COVID-19 immunisations in New Zealand.
[b] Eligibility defined as those aged 16 years and over and received all COVID-19 immunisations in New Zealand.

the pandemic continued to result in overall low disease incidence and very low mortality by international comparisons.[19,20] However, after the first wave, inequities in COVID-19 and severe outcomes were persistently experienced by Māori and Pacific peoples, including higher rates of disease, and 2·6-fold and 5·1-fold the age-standardised risk of hospitalisation and 4-fold and 9-fold the age-standardised risk of death, respectively, of European or Other. Similar to New Zealand's first wave, more affluent, predominantly European or Other and Asian 'healthy travellers' presented with COVID-19 at the border, while incursions led to superspreading events among Pacific peoples and Māori communities in Auckland.

Ethnic disparities in vaccine access for Māori and Pacific peoples alongside easing of non-pharmaceutical interventions likely worsened COVID-19 disparities. A second wave of Delta-related hospitalisations affecting Māori and Pacific peoples in Auckland followed 22 September easing. Non-compliance with lockdown measures and economic impacts were cited as reasons for easing, although was legally disputed.[21] Notably, Delta cases declined after further easing on 3 December. Requirements for crossing the Auckland border ahead of the Christmas holidays possibly contributed to this. High testing rates, low test positivity, and the decline in hospitalisations do not suggest major case ascertainment bias.

Overall, Māori and Pacific peoples receiving age-sequenced second-dose vaccinations had, respectively, 32% and 14% slower access than European or Other. Prioritised age-eligibility for booster dosing was decreased to ≥50 year old Māori and Pacific peoples. However, cumulative disadvantage in access to vaccination likely contributed to Māori and Pacific peoples' 2 to 4-fold higher age-standardised rates of hospitalisation during Omicron, ongoing slower booster vaccination access (even after adjusting for COVID-19 infection), and further lower age-standardised rates of vaccination into the child eligibility phases.

Higher risks of severe COVID-19 outcomes for Māori and Pacific peoples were influenced by factors potentially amenable to targeted interventions. Our finding of approximately 25–49% excess risk of Omicron mortality associated with under-vaccination, after age-sex adjustment, and further approximately 22% excess Omicron mortality risk associated with socio-economic deprivation is comparable to a national estimate for Omicron in 2022.[22] Taken together, the excess hospitalisation and mortality risk estimates for Māori and Pacific peoples associated with under-vaccination, socio-economic deprivation and comorbidities in our study accounted for 80–98% excess Omicron mortality risk after age-sex adjustment. This supports international research for the prioritisation of pandemic response measures to specific communities based on ethnicity,[23–25] socio-economic deprivation,[26,27] and comorbidity,[28] in addition to older age, to mitigate inequities.

Our findings have implications for strategies to mitigate ethnic disparities in the response to future emerging infectious diseases, and support Māori and Pacific leaders' and legislators' recommendations during the response.[9,21] New Zealand initially prioritised limited vaccine supply by exposure risk, and disease vulnerability, including limited targeting of Māori and Pacific peoples ≥65 years. Health districts, Māori and Pacific organisations and communities employed various local strategies, including Māori and Pacific-led vaccination clinics in communities at increased risk. However, funding of Māori and Pacific healthcare providers was delayed, contributing to access barriers.[21] Despite resilience, these communities experienced multiple disadvantages.[9] Considering Health in All Policies to address inequities in the upstream determinants of health remains vital.[1,29] New Zealand's experience further supports evidence-informed stringent public health responses against pandemic threats, Treaty-based approaches in response planning and delivery, and equity-focused prioritisation to achieve health equity.[2,30]

This study has a number of strengths. We linked comprehensive national health datasets to create a highly complete national cohort. Moreover, data were extracted after national data quality reviews, including differentiating hospitalisations and deaths attributed to COVID-19 (excluding incidental diagnoses or social care-related admissions). Total response ethnicity was used to reduce undercounting of Pacific and Asian peoples as occurs with prioritised hierarchical classification.[16] Furthermore, use of the Stats NZ population dataset aimed to reduce undercounting of Māori which occurs in NHI-derived population datasets.[17] Excluding people receiving vaccinations overseas from vaccine uptake analyses also sought to ensure an equitable focus on the protection of New Zealand residents. Those excluded were predominantly European or Other and Asians, consistent with the pattern of returning expatriates during the pandemic.

There are also limitations to consider. Residual elevated risk of hospitalisation for Māori and Pacific peoples after multivariable adjustment is likely influenced by unmeasured factors, including structural racism affecting healthcare quality and access.[31] However, we were unable to assess a potential role of increased exposure risk and could not adjust for household size (which tends to be larger for Māori and Pacific peoples), institutional settings, or high-risk occupations in calculations of case rates.[28,32,33] These data were unavailable at the national level. Although beyond the scope of this study, multivariable analyses conducted at local scales, in locations where more high-quality data are available, could help identify the importance of such variables and further our understanding of residual confounding and causal pathway effects. This could provide the stimulus for conducting prospective studies aimed at improving the quality and availability of data on key variables. The M3 index may have misclassified the presence, absence or severity of some patients' comorbidities, including cases not recently accessing hospital services.[14] The index has been shown to identify substantial disparities for Māori and Pacific peoples compared with European or Other in the prevalence of the conditions it covers, including those associated with more severe COVID-19 outcomes.[15] However, unmeasured comorbidities may still have under-estimated the contribution of comorbidity to excess risk estimates for Māori and Pacific peoples in our study, as Māori and Pacific peoples are more likely to have underdiagnosed comorbidities due to unmet healthcare need and to develop comorbidities at a younger age.[15,31] Accordingly, Māori and Pacific leaders advocated that vaccine prioritisation account for this. For the AFT analysis, inspection of AFT model residuals demonstrated a slight right skewness which may underestimate time-to-vaccination for a small portion of our sample. However, this was not systematic and is

unlikely to affect time ratio estimates. Finally, we acknowledge the diversity within New Zealand's major ethnic groupings. Even using total response ethnicity, the limitations of New Zealand's ethnicity classification in health and population data are serious, with significant differences between Stats NZ and HSU datasets expected to over and under-represent different ethnic groups.[17,18] Improving these datasets are imperative for the monitoring and response to inequities.

In conclusion, New Zealand's stringent two-year pandemic response resulted in low overall burden of COVID-19 but striking ethnic disparities affected Māori and Pacific peoples. Early investment and vaccine programme planning with high-risk communities, prioritisation which accounts for systematic ethnic disadvantage, and the ongoing need to prioritise equity at all key response decisions are key considerations for future responses. There is an urgent need to address inequities in the social determinants of health and the management of comorbidities to reduce the risk of adverse outcomes before the next pandemic.

Data sharing statement

All study data were extracted from national datasets and can be obtained for research purposes with appropriate approvals by contacting survqueries@esr.cri.nz and data-enquiries@health.govt.nz.

Author statements

Ethical approval

Ethical approval was obtained from the University of Otago Human Ethics Committee (Health) (HD20/062).

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Competing interests

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2025.105732.

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