Title

COVID-19 paediatric vaccination coverage and associated factors among migrant and non-migrant children in Aotearoa New Zealand: A population-level retrospective cohort study

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Panel: Putting research into context

Evidence before this study

International literature points to higher burden of vaccine-preventable diseases (VPDs) and lower immunisation coverage rates among migrants and refugees compared to their host populations due to a complex myriad of factors. Our previous research in Aotearoa New Zealand (NZ) reported suboptimal uptake of routine childhood immunisations among children with migrant and refugee backgrounds, especially those born overseas. Uptake of the paediatric COVID-19 vaccine has been mediocre in NZ and other high-income countries, with notable inequities by socio-demographic characteristics.

Added value of this study

Our study examined uptake of the paediatric COVID-19 vaccine among 5-11 year olds in NZ using population-level data (N = 451,323). Significantly higher COVID-19 vaccination rates were reported among children with migrant and refugee backgrounds compared to non-migrant children. This study found several significant factors influencing COVID-19 vaccination rates, including ethnicity, gender, age, family type, household income, deprivation, region, parent COVID-19 vaccination status and child's previous COVID-19 infection. Parents' COVID-19 vaccination status was the largest contributing factor on a child's likelihood of receiving a COVID-19 vaccine dose.

Implications of all available evidence

Despite national efforts for an equitable paediatric COVID-19 vaccine rollout, inequities in uptake exist. On the contrary to most international literature pertaining to routine childhood and COVID-19 vaccinations, our study found that migrant children had higher uptake compared to non-migrant children. NZ's efforts to address commonly identified barriers to vaccine access and acceptance may have supported COVID-19 vaccine uptake among migrants. To improve uptake, tailored efforts are needed to address parental vaccine hesitancy, and logistical and motivational barriers to COVID-19 vaccination.

ABSTRACT

Background

Children with migrant and refugee backgrounds may experience immunisation inequities due to barriers to accessing and accepting vaccines. In Aotearoa New Zealand (NZ), national reporting can mask inequities in coverage by migration background.

Methods

This population-level retrospective cohort study explored rates and determinants of paediatric COVID-19 vaccine uptake as of July 2022 amongst migrant and non-migrant children who were aged between 5-11 years old as of January 2022. Linked de-identified administrative and health data available in Statistics NZ's Integrated Data Infrastructure were used, and univariate and multivariable logistic regression were conducted to determine associations.

Findings

Of the total study population (N = 451,323), 3.5% were overseas-born migrant children, 31.3% were NZ-born migrant children, and 65.3% were NZ-born non-migrant children. Only 50.8% (229,164 out of 451,323) of children had received at least one dose. Migrant children were significantly more likely to have received a COVID-19 vaccination compared to non-migrant children. Logistic modelling revealed that all factors, including ethnicity, gender, age, family type, household income, deprivation, region, parent COVID-19 vaccination status and child's previous COVID-19 infection significantly influenced COVID-19 vaccine uptake. The largest contributing factor was parents' COVID-19 vaccination status.

Interpretation

The findings suggest that NZ's paediatric COVID-19 vaccination programme was able to address logistical and motivational barriers commonly identified amongst migrants and refugees. As parents' vaccination status is an important factor in vaccinating their own children, continuous efforts are needed to support confident parental COVID-19 vaccine decision-making. To address social inequities, engagement with marginalised communities to co-design tailored and localised approaches are recommended.

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Introduction

On 12 March 2020, the World Health Organisation (WHO) declared a pandemic due to a novel coronavirus named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Ciotti et al., 2020). The virus spread globally and, as of January 2023, the coronavirus disease (COVID-19) has caused over 750 million cases and over 6.8 million deaths (World Health Organisation, n.d.). Rapidly vaccinating the global population, when the first COVID-19 vaccines were authorised at the end of 2020, has positively resulted in reducing transmission and severe outcomes, and preventing millions of deaths (Watson et al., 2022).

Age is an important determinant of COVID-19 severity. Children have been reported to be less symptomatic and susceptible to infection compared to adults (Blanchard-Rohner et al., 2021). However, children still contribute to transmission and are also at risk of severe disease and complications, including multisystem inflammatory syndrome (MIS-C) (Blanchard-Rohner et al., 2021). During the COVID-19 pandemic, children also experienced wide-ranging impacts associated with implemented mitigation measures that have negatively impacted their mental health and wellbeing (Patrick et al., 2020; Samji et al., 2022).

Although the benefit-risk analysis of COVID-19 vaccination in children has been debated (Blanchard-Rohner et al., 2021), paediatric COVID-19 vaccines were approved for use and rolled out in countries like Canada, the United States and Australia in the beginning of late 2021/early 2022 (Australian Government, 2021; Government of Canada, 2021; Woodworth et al., 2021). Despite national recommendations, paediatric COVID-19 coverage rates for 5 to 11 year olds in these countries have been suboptimal. Recent reports show that only 31% (United States), 41% (Canada), and 40% (Australia) of 5 to 11 year olds have completed the primary series (American Academy of Pediatrics, 2022; Australian Government, 2022; Government of Canada, 2022). Moreover, there are notable inequities in uptake by age, ethnicity, and region (Murthy et al., 2022; Steffens et al., 2022; Valier et al., 2023).

In Aotearoa New Zealand (NZ), the paediatric COVID-19 vaccine programme began in January 2022 and involved two publicly funded paediatric doses of the Pfizer vaccine 8 weeks apart (Ministry of Health, 2022b). COVID-19 vaccination is voluntary (no vaccine mandate) and freely available for all children regardless of their immigration and citizenship status (Ministry of Health, 2023). In NZ, while the majority (90.2%) of the 12+ population have completed their primary course, uptake has been mediocre among 5 to 11 year olds (Ministry of Health, 2022c). To date, less than 30% of eligible children have completed the primary course and half of children are partially vaccinated - well below the 90% national target (Ministry of Health, 2022c). Importantly, inequities in coverage are noted by ethnicity and region (Ministry of Health, 2022c).

National coverage data does not report rates by migration background. NZ has experienced positive net migration with various pathways to enter, although this trend has been impacted by the COVID-19 pandemic and border restrictions (Stats NZ, n.d.). Previous NZ research has revealed suboptimal and inequitable uptake for nationally recommended (routine) vaccines among overseas-born children with migrant and refugee backgrounds (Charania et al., 2022; Charania et al., 2018). Globally, immunisation coverage disparities between migrants and non-migrants have been reported for routine vaccines, citing various contributing factors, including income, geographic origin, and language proficiency, to name a few (Charania et al., 2019; Crawshaw et al., 2022; Deal et al., 2022).

Differences in adult COVID-19 vaccination coverage by migration background have been previously reported (Biddle et al., 2022; Fuhrer et al., 2022; Holz et al., 2022; MacDonald et al., 2022). However, similar information for children is non-existent as the limited literature to date has only examined paediatric COVID-19 coverage stratifying by age, sex, ethnicity, and geographic region (Murthy et al., 2022; Valier et al., 2023). Canadian studies have noted the influence of parents' being born overseas on their intention or reported vaccination of their children against COVID-19 (Humble et al., 2022; McKinnon et al., 2021).

Given the immunisation inequities migrant and refugee background populations can experience regarding routine vaccines, and common barriers they face to accessing immunisation services, it is important to investigate if inequities exist in COVID-19 paediatric vaccine uptake by migration background. The presented study used logistic regression models to account for the many factors that can explain differences in vaccination coverage by migration background (Charania et al., 2019; Crawshaw et al., 2022; Deal et al., 2022). NZ's unique data collection capabilities support robust data linkages across various databases, including immigration and immunisation data, for a national sample of children. To our knowledge, this is the first study to explore national paediatric COVID-19 vaccine uptake rates and contributing factors among migrant and non-migrant background children.

Methods

Participants

This study looks at the uptake of the paediatric COVID-19 vaccination as of July 2022 across three NZ cohorts of children who were aged between 5 and 11 (inclusive) as of January 2022. Of the total study population (N = 451,323), 3.5% were overseas-born migrant children (Cohort A), 31.3% were NZ-born children of migrant parents (Cohort B), and 65.3% were NZ-born non-migrant children (Cohort C). For all cohorts, children were excluded if they were deceased, had moved permanently overseas, or had spent less than six months in New Zealand as of January 2022. Additionally, children who had opted out of the National Immunisation Register (NIR) or could not be linked to parents were excluded from the analysis.

Data Collection and Measures

Individual-level anonymised administrative data from the Integrated Data Infrastructure (IDI) was used to generate explanatory and outcome variables for this study. The IDI is a centralised collection of New Zealand whole-population administrative datasets that spans several sectors such as health, social services, and education. It is managed by Stats NZ which is New Zealand's official data agency which collects and collates information on individuals and businesses from various government agencies. Individuals who have interacted with government services are assigned a unique, confidential, and anonymised identifier. This allows multiple datasets to be linked at the individual level from various government departments including the Stats NZ-derived Personal Details and Address Notification dataset for demographic variables such as prioritised ethnicity, age, gender and deprivation level;[1] Department of Labour Decisions dataset for visa types; Ministry of Health National Enrolment Service dataset for regional enrolment in the health system; Ministry of Business, Innovation and Employment Border Movement and NZ Customs Journeys dataset for immigration and travel data (e.g., date of entry, country of citizenship, nationality based on earliest arrival, time spent in NZ); Department of Internal Affairs for birth data; 2018 Census for family type

[1] Prioritised ethnicity in order of: Māori, Pacific Peoples, Asian, MELAA (Middle Eastern, Latin America or African), European, Other

and household income.[2] Of primary interest was the Ministry of Health COVID Immunisation Register (CIR) which records each COVID-19 vaccination event for an individual. Additionally, the COVID Tests dataset records the results of PCR and RAT COVID-19 tests reported to the Ministry of Health. The CIR was used to create the binary outcome measure equal to 1 if a child had received at least one dose of the COVID-19 vaccination as of July 2022, 0 otherwise. This dataset was also used to determine whether parent had received no, one or at least two doses of the COVID vaccine. The June 2022 refresh for the IDI was used.

Analysis

Selection of relevant data, data linkage and variable creation were done using SQL Server 2018 and R Studio. Several factors can explain differences in the uptake of the paediatric COVID-19 vaccination. Therefore, a logistic regression model is used to estimate the likelihood of receiving at least one dose of the COVID-19 vaccination, controlling for several explanatory variables that help explain the variation in uptake between NZ-born migrant and non-migrant children (Equation 1). Selection of explanatory variables used in the regression was based on prior literature related to differences in vaccination uptake for routine immunisations among migrants and refugees (Charania et al., 2019; Crawshaw et al., 2022; Deal et al., 2022).

$$logit(p_i) = \alpha + \beta_1 C_i + \beta_i' X_i' \gamma \qquad (1)$$

With subscript *i* referring to individual *i* = 1, …, *N*. Terms starting from the lefthand side:

- Where p_i measures the likelihood of individual *i* having received at least one COVID vaccination ($where \Pr(y_i = 1)$) between January 2022 and July 2022 (inclusive)
- C_i is a categorical cohort variable which measures which cohort a child belongs to, with Cohort C being the reference cohort.
- X_i' is a matrix of individual-level explanatory variables that includes:
    - Sex at birth (reference group: female)
    - Age (continuous variable)
    - Family income (reference group: low income)[3]
    - Family type (reference group: couple with children)[4]

[2] The 2018 Census variables for family type and household income was available for 96.5% of the study population, with 25.8% of Cohort A (overseas-born migrants) having arrived after the 2018 Census. Characteristics of the potentially missed population in Cohort A were children with refugee or Pacific humanitarian backgrounds and/or identified as MELAA or Pacific. Proxy variables for family type and household income were created using the Address Notification and Inland Revenue Annual Income data for 2021. These variables were coded to the 2018 Census variable if it existed, or else to the proxy variable. Imputation accounted for 3.5% of the total study population. Similar coefficients for the Census variable compared to the imputed variable were obtained, giving confidence that the imputed variable was robust.

[3] Family income is divided into three annual income bands in New Zealand dollars: Low (< $25,000), Medium ($25,000 - $69,999) and High ($70,000 +). This is taken from the household income question in the 2018 Census if families were in New Zealand prior to the Census. For families that arrived after the 2018 Census, the authors used annual 2021 household income from wages and salary (from both mother and father) as an imputed variable.

[4] Family type as per the 2018 Census is categorised as couple with children, single parent with children or couple with no children. As the analysis focuses on the child population, family type can be both parents and sole parents. This is taken from the family type question in the 2018 Census if families were in New Zealand prior to the Census. For families that arrived after the 2018 Census, the authors use linked parent and address data to identify if parents lived at the same address as the child as an imputed variable.

- Deprivation (reference group: quintile 1) (University of Otago, n.d.)[5]
- Primary Health Organisation (PHO) region (reference group: Auckland) (Medical Council of New Zealand, n.d.; Ministry of Health, 2022a)[6]
- Parent's highest COVID dose number (reference group: 2+ doses)
- COVID flag equal to 1 if child has had COVID

The literature suggests that parents' English ability, education, and number of dependents influence vaccination decisions. These variables were only available for children whose parents participated in the 2018 Census which covered 96.5% of the study population. The inclusion of these variables would exclude 25.8% of overseas-born migrant children (Cohort A) who arrived after the 2018 Census and therefore had no corresponding value for parent's English ability, education and number of dependents. Logistic regression modelling drops observations with missing values and therefore regressions including these variables would exclude a large proportion of Cohort A. As a robustness check, these variables were included in initial models to test their significance with the 2018 Census population; however, these did not explain much of the variation in likelihood of being vaccinated for COVID-19. In order to include as many individuals in the overseas-born migrant children in the Cohort A sample, these variables were excluded from the final model.[7]

Results

Description of cohorts

The demographic characteristics of children in all three cohorts are presented in

[5] Deprivation is based on the New Zealand Index of Deprivation (2018) which provides area-based socioeconomic deprivation . It is based on an ordinal scale from 1 to 10 and grouped into quintiles from 1 to 5, where quintile 1 represents the areas with the least deprivation and quintile 5 representing areas with the most deprivation. This is different to family income as family income pertains to an individual and their family whereas deprivation relates to an area where the individual resides.

[6] At the time of the study, New Zealand's primary care health system was divided into 20 regional District Health Boards (DHBs), which were made up of 30 Primary Health Organisations (PHOs). PHOs are responsible for delivering primary health services to individuals residing in each PHO.

[7] English ability was largely insignificant. Parents' education was largely insignificant, as variation was mostly explained by parents' household income and deprivation and therefore offered little explanatory power in the model. Number of dependents was slightly significant; however, this was excluded from the model to allow for non-Census participants to be included in the final model.

Table *1*. There was uniform distribution by ethnicity (Māori, Pacific Peoples, Asian, European) among overseas-born migrant children (Cohort A). The median length of time children in Cohort A had lived in New Zealand was 6.3 years [LQ 4.5 – UQ 8.3]. Over half (51.4%) did not require a visa when entering New Zealand, with the next largest visa group being those arriving on a visitor visa (15.7%), refugee visa (8.7%) and Pacific humanitarian visa (8.0%). Among overseas-born migrant children, 48.3% were from parents with citizenship of Australia or New Zealand, followed by Polynesia (11.9%) and Southern Asia (9.3%). Almost one-fifth (18.3%) of overseas-born migrant children were not enrolled in primary health care services, with one third (33.4%) living in the most deprived areas.

Among NZ-born migrant children (Cohort B), the largest share by ethnicity was Asian (37.0%), followed by European (35.4%). The median number of years parents of NZ-born migrant children had been in NZ was 16.7 years [LQ 12.7 – UQ 20.8], with those on work visas (29.6%) making up the largest share by visa group, followed by visitors (22.9%) and then those who did not require visas to enter NZ (20.6%). Parents of NZ-born migrant children were predominantly from Australia and New Zealand (19.8%), followed by Eastern Asia (15.2%) and Northern Europe (14.5%). Only 1% of NZ-born migrant children were not enrolled with primary health care services, with the distribution of children living in the least to most deprived areas being uniform across quintiles.

Almost half of the NZ-born non-migrant children (Cohort C) identified as European (49%), with Māori, the indigenous people of NZ, making up 39.8% of the cohort. Less than 1% of NZ-born non-migrant children were not enrolled with primary health care services, with 22.6% living in the most deprived areas.

Table 1. Demographic characteristics of children in Cohorts A (overseas-born migrants), B (NZ-born migrants) and C (NZ-born non-migrants)

	Cohort A (child) N = 15,678		**Cohort B (parents) N = 141,123**		**Cohort C N = 294,522**	
Average age	8.7		7.9		8.1	
	6.3		16.7			
Median years since arrival	[LQ 4.5 – UQ 8.3]		[LQ 12.7 – UQ 20.8]		-	
Sex at birth	**n**	**%**	**n**	**%**	**n**	**%**
Male	8,019	51.1%	72,558	51.4%	151,071	51.3%
Female	7,659	48.9%	68,565	48.6%	143,451	48.7%
Ethnicity	**n**	**%**	**n**	**%**	**n**	**%**
Māori	3,135	20.0%	12,927	9.2%	117,345	39.8%
Pacific	3,321	21.2%	19,725	14.0%	22,161	7.5%
Asian	4,317	27.5%	52,263	37.0%	8,358	2.8%
MELAA[a]	1,296	8.3%	5,310	3.8%	954	0.3%
European	3,501	22.3%	49,962	35.4%	144,255	49.0%
Other	105	0.7%	936	0.7%	1,446	0.5%
Family Type (imputed)	**n**	**%**	**n**	**%**	**n**	**%**
Couple with children	7,779	49.6%	116,727	82.7%	199,686	67.8%
One parent with children	6,675	42.6%	20,613	14.6%	81,210	27.6%
Unknown	1,224	7.8%	3,786	2.7%	13,626	4.6%
Household Income (imputed)	**n**	**%**	**n**	**%**	**n**	**%**
Low (< $25,000)	4,830	30.8%	18,582	13.2%	52,746	17.9%
Medium ($25,000 - $69,999)	6,252	39.9%	39,273	27.8%	81,426	27.6%
High ($70,000 +)	3,369	21.5%	79,485	56.3%	146,724	49.8%
Unknown	1,221	7.8%	3,783	2.7%	13,626	4.6%
PHO region	**n**	**%**	**n**	**%**	**n**	**%**
Auckland	2,067	13.2%	27,492	19.5%	33,981	11.5%
Bay of Plenty	564	3.6%	4,587	3.3%	13,710	4.7%
Canterbury	1,023	6.5%	13,791	9.8%	29,409	10.0%
Capital and Coast	705	4.5%	9,732	6.9%	15,846	5.4%
Counties Manukau	2,202	14.0%	24,417	17.3%	24,111	8.2%
Hawkes Bay	447	2.9%	3,363	2.4%	12,222	4.1%
Hutt Valley	360	2.3%	3,813	2.7%	8,859	3.0%
Lakes	309	2.0%	2,292	1.6%	9,708	3.3%
MidCentral	429	2.7%	3,411	2.4%	12,906	4.4%
Nelson Marlborough	450	2.9%	3,399	2.4%	9,189	3.1%
Northland	459	2.9%	2,919	2.1%	14,721	5.0%
South Canterbury	96	0.6%	1,158	0.8%	4,713	1.6%
Southern	525	3.3%	5,547	3.9%	17,805	6.0%
Tairawhiti	165	1.1%	936	0.7%	5,319	1.8%
Taranaki	234	1.5%	2,340	1.7%	9,636	3.3%
Waikato	1,194	7.6%	10,746	7.6%	36,300	12.3%
Wairarapa	93	0.6%	963	0.7%	4,062	1.4%
Waitemata	1,239	7.9%	16,863	11.9%	20,238	6.9%
West Coast	66	0.4%	609	0.4%	2,766	0.9%
Whanganui	189	1.2%	1,284	0.9%	6,918	2.3%
Not enrolled	2,871	18.3%	1,458	1.0%	2,100	0.7%
Deprivation	**n**	**%**	**n**	**%**	**n**	**%**
Quintile 1 (Lowest)	1,518	9.7%	27,405	19.4%	46,479	15.8%

Quintile 2	2,067	13.2%	26,052	18.5%	47,985	16.3%
Quintile 3	2,631	16.8%	25,005	17.7%	50,394	17.1%
Quintile 4	3,303	21.1%	23,874	16.9%	56,979	19.3%
Quintile 5 (Highest)	5,229	33.4%	27,939	19.8%	78,291	26.6%
Missing	930	5.9%	10,848	7.7%	14,391	4.9%
Visa group	**n**	**%**	**n**	**%**	**n**	**%**
Family	618	3.9%	7,491	5.3%	-	-
International Humanitarian[b]	36	0.2%	831	0.6%	-	-
Medical Treatment	S	S	75	0.1%	-	-
No visa required[c]	8,058	51.4%	29,055	20.6%	-	-
Other	S	S	1,026	0.7%	-	-
Overstay	57	0.4%	729	0.5%	-	-
Pacific Humanitarian[d]	1,257	8.0%	1,821	1.3%	-	-
Refugee	1,371	8.7%	2,121	1.5%		
Resident	576	3.7%	2,172	1.5%	-	-
Student	312	2.0%	21,816	15.5%	-	-
Visitor	2,460	15.7%	32,268	22.9%	-	-
Work	927	5.9%	41,721	29.6%	-	-
UN Region	**n**	**%**	**n**	**%**	**n**	**%**
Africa	**573**	**3.7%**	**8,583**	**6.1%**	-	-
Americas	**591**	**3.8%**	**7,008**	**5.0%**		
North America	321	2.0%	4,338	3.1%	-	-
South America	249	1.6%	2,424	1.7%	-	-
Central America/ Caribbean/Latin America	15	0.1%	249	0.2%	-	-
Asia	**4,020**	**25.6%**	**49,155**	**34.8%**		
Eastern Asia	1,050	6.7%	21,504	15.2%	-	-
Southern Asia	1,455	9.3%	15,375	10.9%	-	-
South-East Asia	993	6.3%	10,932	7.7%	-	-
Central and Western Asia	522	3.3%	1,347	1.0%	-	-
Europe	**747**	**4.8%**	**26,883**	**19.0%**		
Northern Europe	549	3.5%	20,460	14.5%	-	-
Rest of Europe	198	1.3%	6,426	4.6%	-	-
Oceania	**9,732**	**62.1%**	**49,404**	**35.0%**		
Australia and New Zealand	7,572	48.3%	28,002	19.8%	-	-
Micronesia and Melanesia	300	1.9%	7,857	5.6%	-	-
Polynesia	1,863	11.9%	13,533	9.6%	-	-
Missing	15	0.1%	93	0.1%	-	-

Source: IDI and author analyses. Note: in order to meet privacy protection requirements of Stats NZ, counts have been randomly rounded to base 3. Cells denoted S are suppressed to follow confidentiality rules.

[a] Middle Eastern, Latin American and African

[b] Visas include 1991 and 1995 Humanitarian, Ministerial Direction, Zimbabwe Policy, Victims of Domestic Violence, Christchurch Response

[c] Parents did not require a visa to enter New Zealand – from New Zealand, Pacific Nations (Cook Islands, Niue, Tonga) and Australia

[d] Visas include Pacific Access Category Visa for Tonga, Tuvalu, Fiji, Kiribati, and Samoan Quota Visa

COVID-19 vaccination status

Table *2* provides the number of children who have received or not received the COVID-19 vaccination by demographic characteristics. These are bivariate descriptive statistics that are not causal in nature. The uptake of COVID-19 vaccination was modest across all three cohorts of children, with only 50.8% (229,164 out of 451,323) of the study participants being vaccinated with at least one dose. The lowest uptake of the COVID-19 vaccination was among NZ-born non-migrant children, with less than half (46.3%) having received the COVID-19 vaccination. In comparison, the

NZ-born migrant children had the highest uptake (60.1%), followed by overseas-born migrant children (51.7%).

For all three cohorts of children, Māori children had the lowest proportion of children who received the COVID-19 vaccination. Among overseas and NZ-born migrant children, Asian children had the highest uptake of the COVID-19 vaccination. Across all three cohorts, children where both parents were together had higher uptake of the COVID-19 vaccination, compared to those with only one parent. Children in low-income households had the lowest proportion of children who received the COVID-19 vaccination; this is consistent across all cohorts. Similarly, as deprivation increased, the lower the proportion of children who had been vaccinated. Among migrant children, those who were not enrolled in primary health care services or enrolled in Auckland, Counties Manukau and Waikato had the lowest uptake of the COVID-19 vaccination. For overseas-born migrant children, those who arrived in New Zealand with no visa had the lowest vaccination rates. The proportion of migrant children from Asia vaccinated for COVID-19 was twice of that for those who were not vaccinated. For migrant children from Africa, Americas and Europe, the proportion of children having received or not received a COVID-19 vaccination was similar. For overseas-born migrant children from Oceania, the higher proportion having not received a COVID-19 vaccination is driven by children from Australia and New Zealand.

Table *3* presents the results of the logistic regression. Overseas and NZ-born migrant children were significantly more likely [odds ratio (OR) 1.24, 95% confidence interval (CI) 1.19 – 1.30; OR 1.18, CI 1.16 – 1.20] to have received a COVID vaccination, compared to children in Cohort C after adjusting for ethnicity, gender, age, family type, household income, PHO region, parent COVID-19 vaccination status and if the child has had COVID. Māori, MELAA and Pacific children were significantly less likely to have received a COVID vaccination, while Asian children were significantly more likely to have received a COVID vaccination compared to European children. Male children were less likely to have received a COVID vaccination compared to female children. The likelihood of receiving a COVID vaccination increased with age. Children who had one parent were less likely to receive a COVID vaccination, compared to those with both parents. Children in medium and high-income households were more likely to be vaccinated compared to those in low-income households, with the likelihood of receiving a COVID vaccination decreasing with increased deprivation. Children enrolled in primary health care services in Bay of Plenty, Lakes, Northland, and Taranaki regions had the lowest likelihood of receiving a COVID vaccination, while children enrolled in the Capital and Coast region have the highest likelihood, compared to children enrolled in Auckland. Children whose parents had received only one or no COVID vaccinations were significantly less likely to have received a COVID vaccination, compared to children whose parents had received at least two doses. This was the largest contributing factor on a child's likelihood of receiving the COVID vaccination amongst all available factors. Children who reported having COVID were more likely to receive a COVID vaccination compared to those that did not report having COVID.

Table 2. COVID-19 vaccination status by cohort demographic characteristics

	Cohort A (child) N = 15,678				Cohort B (parents) N = 141,123				Cohort C N = 294,522			
	Yes	**(%)**	**No**	**(%)**	**Yes**	**(%)**	**No**	**(%)**	**Yes**	**(%)**	**No**	**(%)**
COVID-19												
COVID-19 vaccinated	8,097	51.6%	7,578	48.3%	84,747	60.1%	56,376	39.9%	136,320	46.3%	158,202	53.7%
Have had COVID-19	2,097	13.4%	13,584	86.6%	20,622	14.6%	120,498	85.4%	53,196	18.1%	241,329	81.9%
Vaccinated same day as parent	1,995	12.7%	13,683	87.3%	22,668	16.1%	118,455	83.9%	36,135	12.3%	258,387	87.7%
	COVID-19 vaccination status											
Sex at birth												
Male	4,035	50.3%	3,987	49.7%	43,413	59.8%	29,142	40.2%	69,498	46.0%	81,573	54.0%
Female	4,065	53.1%	3,594	46.9%	41,334	60.3%	27,234	39.7%	66,822	46.6%	76,629	53.4%
Ethnicity												
Māori	945	30.1%	2,190	69.9%	5,577	43.1%	7,350	56.9%	39,066	33.3%	78,282	66.7%
Pacific	1,839	55.3%	1,485	44.7%	9,843	49.9%	9,885	50.1%	9,237	41.7%	12,927	58.3%
Asian	3,003	69.5%	1,317	30.5%	36,153	69.2%	16,110	30.8%	5,733	68.6%	2,625	31.4%
MELAA[a]	549	42.5%	744	57.5%	2,406	45.3%	2,904	54.7%	489	51.3%	465	48.7%
European	1,710	48.8%	1,791	51.2%	30,216	60.5%	19,746	39.5%	81,006	56.2%	63,252	43.8%
Other	54	50.0%	54	50.0%	552	59.2%	381	40.8%	792	54.8%	654	45.2%
Family Type (imputed)												
Couple with children	4,527	58.2%	3,252	41.8%	72,774	62.3%	43,956	37.7%	105,909	53.0%	93,777	47.0%
One parent with children	3,096	46.4%	3,579	53.6%	10,287	49.9%	10,323	50.1%	26,814	33.0%	54,396	67.0%
Unknown	474	38.7%	750	61.3%	1,686	44.6%	2,097	55.4%	3,597	26.4%	10,029	73.6%
Household Income (imputed)												
Low (< $25,000)	2,199	45.5%	2,634	54.5%	8,691	46.8%	9,891	53.2%	14,610	27.7%	38,136	72.3%
Medium ($25,000 - $69,999)	3,309	52.9%	2,943	47.1%	21,111	53.8%	18,159	46.2%	30,399	37.3%	51,024	62.7%
High ($70,000 +)	2,118	62.9%	1,251	37.1%	53,262	67.0%	26,226	33.0%	87,711	59.8%	59,013	40.2%

Unknown	474	38.7%	750	61.3%	1,686	44.6%	2,097	55.4%	3,597	26.4%	10,029	73.6%
PHO region												
Auckland	1,230	59.4%	840	40.6%	17,217	62.6%	10,272	37.4%	18,369	54.1%	15,609	45.9%
Bay of Plenty	219	38.8%	345	61.2%	2,091	45.6%	2,496	54.4%	4,719	34.4%	8,991	65.6%
Canterbury	612	59.6%	414	40.4%	8,310	60.3%	5,481	39.7%	16,269	55.3%	13,140	44.7%
Capital and Coast	429	60.9%	276	39.1%	6,936	71.2%	2,799	28.8%	10,191	64.3%	5,658	35.7%
Counties Manukau	1,284	58.3%	918	41.7%	15,342	62.8%	9,078	37.2%	10,656	44.2%	13,455	55.8%
Hawkes Bay	207	46.6%	237	53.4%	1,704	50.6%	1,662	49.4%	4,833	39.5%	7,389	60.5%
Hutt Valley	234	65.0%	126	35.0%	2,553	67.0%	1,260	33.0%	4,833	54.6%	4,023	45.4%
Lakes	111	35.9%	198	64.1%	1,164	50.8%	1,128	49.2%	3,261	33.6%	6,447	66.4%
MidCentral	225	52.4%	204	47.6%	2,037	59.7%	1,374	40.3%	5,889	45.6%	7,017	54.4%
Nelson Marlborough	252	56.0%	198	44.0%	1,941	57.2%	1,455	42.8%	4,371	47.6%	4,818	52.4%
Northland	144	31.4%	315	68.6%	1,332	45.6%	1,590	54.4%	4,377	29.7%	10,341	70.3%
South Canterbury	54	58.1%	39	41.9%	684	59.2%	471	40.8%	2,220	47.1%	2,493	52.9%
Tairawhiti	81	49.1%	84	50.9%	474	50.5%	465	49.5%	2,298	43.2%	3,021	56.8%
Taranaki	93	39.7%	141	60.3%	1,236	52.8%	1,107	47.2%	3,915	40.6%	5,721	59.4%
Southern	255	48.3%	273	51.7%	3,147	56.7%	2,400	43.3%	8,928	50.1%	8,880	49.9%
Waikato	504	42.3%	687	57.7%	5,853	54.5%	4,896	45.5%	14,211	39.1%	22,089	60.9%
Wairarapa	54	58.1%	39	41.9%	540	56.3%	420	43.8%	1,734	42.7%	2,331	57.3%
Waitemata	738	59.7%	498	40.3%	10,698	63.4%	6,165	36.6%	10,905	53.9%	9,333	46.1%
West Coast	33	52.4%	30	47.6%	336	54.9%	276	45.1%	1,251	45.3%	1,512	54.7%
Whanganui	66	34.9%	123	65.1%	681	52.9%	606	47.1%	2,655	38.4%	4,266	61.6%
Not enrolled	1,275	44.5%	1,593	55.5%	474	32.5%	984	67.5%	444	21.1%	1,656	78.9%
Deprivation												
Quintile 1 (Lowest)	897	59.1%	621	40.9%	18,759	68.5%	8,646	31.5%	29,754	64.0%	16,722	36.0%
Quintile 2	1,134	54.9%	933	45.1%	16,701	64.1%	9,351	35.9%	26,658	55.6%	21,327	44.4%
Quintile 3	1,413	53.8%	1,215	46.2%	14,955	59.8%	10,050	40.2%	24,618	48.8%	25,779	51.2%
Quintile 4	1,674	50.7%	1,629	49.3%	13,470	56.4%	10,404	43.6%	23,469	41.2%	33,513	58.8%
Quintile 5 (Highest)	2,466	47.2%	2,763	52.8%	14,139	50.6%	13,800	49.4%	24,810	31.7%	53,484	68.3%

Unknown	513	55.2%	417	44.8%	6,726	62.0%	4,125	38.0%	7,014	48.7%	7,377	51.3%
Visa group												
Family	411	66.2%	210	33.8%	4,779	63.8%	2,715	36.2%	-	-	-	-
International Humanitarian	21	58.3%	15	41.7%	528	63.8%	300	36.2%	-	-	-	-
Medical Treatment	S	S	S	S	36	50.0%	36	50.0%	-	-	-	-
No Visa	3,399	42.2%	4,659	57.8%	16,491	56.8%	12,561	43.2%	-	-	-	-
Other	S	S	S	S	588	57.6%	432	42.4%	-	-	-	-
Overstay	27	47.4%	30	52.6%	315	43.2%	414	56.8%	-	-	-	-
Pacific Humanitarian	789	62.6%	471	37.4%	903	49.6%	918	50.4%	-	-	-	-
Refugee	720	52.4%	654	47.6%	1,050	49.5%	1,071	50.5%	-	-	-	-
Resident	363	63.4%	210	36.6%	1,410	64.9%	762	35.1%	-	-	-	-
Student	S	S	S	S	13,761	63.1%	8,055	36.9%	-	-	-	-
Visitor	1,524	62.0%	936	38.0%	19,131	59.3%	13,137	40.7%	-	-	-	-
Work	618	66.7%	309	33.3%	25,749	61.7%	15,975	38.3%	-	-	-	-
UN Region												
Africa	**252**	**44.2%**	**318**	**55.8%**	**4,005**	**46.7%**	**4,575**	**53.3%**	-	-	-	-
Americas	**291**	**49.5%**	**297**	**50.5%**	**3,888**	**55.5%**	**3,120**	**44.5%**	-	-	-	-
North America	156	48.6%	165	51.4%	2,538	58.5%	1,800	41.5%	-	-	-	-
South America	120	48.2%	129	51.8%	1,227	50.7%	1,194	49.3%	-	-	-	-
Central America/ Caribbean/ Latin America	S	S	S	S	123	48.8%	129	51.2%	-	-	-	-
Asia	**2,667**	**66.3%**	**1,353**	**33.7%**	**32,541**	**66.2%**	**16,617**	**33.8%**	-	-	-	-
Eastern Asia	735	70.0%	315	30.0%	14,796	68.8%	6,708	31.2%	-	-	-	-
Southern Asia	942	64.9%	510	35.1%	9,591	62.4%	5,781	37.6%	-	-	-	-
South-East Asia	783	78.9%	210	21.1%	7,683	70.3%	3,249	29.7%	-	-	-	-
Central and Western Asia	204	39.3%	315	60.7%	468	34.7%	879	65.3%	-	-	-	-
Europe	**393**	**52.8%**	**351**	**47.2%**	**16,056**	**59.7%**	**10,824**	**40.3%**	-	-	-	-
Northern Europe	327	59.6%	222	40.4%	13,050	63.8%	7,410	36.2%	-	-	-	-
Rest of Europe	69	34.3%	132	65.7%	3,006	46.8%	3,420	53.2%				

Oceania	**4,476**	**46.0%**	**5,256**	**54.0%**	**28,224**	**57.1%**	**21,177**	**42.9%**	-	-
Australia and New Zealand	3,108	41.1%	4,461	58.9%	16,116	57.6%	11,886	42.4%	-	-
Micronesia and Melanesia	201	67.0%	99	33.0%	5,403	68.8%	2,451	31.2%		
Polynesia	1,167	62.7%	693	37.3%	6,699	49.5%	6,834	50.5%		
Missing	**S**	**S**	**S**	**S**	**33**	**35.5%**	**60**	**64.5%**		

Source: IDI and author analyses. Note: in order to meet privacy protection requirements of Stats NZ, counts have been randomly rounded to base 3. Cells denoted S are suppressed to follow confidentiality rules.

[a] Middle Eastern, Latin American and African

Table 3 Logistic regression results comparing three cohorts, adjusting for demographic characteristics

	Odds Ratio	95% CI		P-value	Sig.
Cohort					
A (overseas-born migrant children)	1.24	1.19	1.30	< 0.001	***
B (NZ-born migrant children)	1.18	1.16	1.20	< 0.001	***
C (NZ-born non-migrant children)	*reference*				
Ethnicity					
Asian	1.70	1.66	1.75	< 0.001	***
Māori	0.58	0.57	0.59	< 0.001	***
MELAA[a]	0.64	0.61	0.68	< 0.001	***
Other	1.14	1.04	1.25	0.01	**
Pacific	0.77	0.75	0.79	< 0.001	***
European	*reference*				
Sex at birth					
Male	0.97	0.96	0.99	< 0.001	***
Female	*reference*				
Age at January 2022	1.34	1.33	1.34	< 0.001	***
Family type					
Couple with children	*reference*				
One parent with children	0.86	0.84	0.88	< 0.001	***
Household income					
High	1.94	1.89	1.99	< 0.001	***
Medium	1.18	1.16	1.21	< 0.001	***
Low	*reference*				
Deprivation					
Quintile 1 (Lowest)	*reference*				
Quintile 2	0.85	0.83	0.87	< 0.001	***
Quintile 3	0.76	0.74	0.78	< 0.001	***
Quintile 4	0.69	0.67	0.71	< 0.001	***
Quintile 5 (Highest)	0.61	0.60	0.63	< 0.001	***
PHO Region					
Auckland	*reference*				
Bay of Plenty	0.51	0.49	0.53	< 0.001	***
Canterbury	0.83	0.81	0.86	< 0.001	***
Capital and Coast	1.29	1.24	1.33	< 0.001	***
Counties Manukau	0.90	0.87	0.92	0.0095	***
Hawkes Bay	0.66	0.63	0.69	< 0.001	***
Hutt Valley	1.04	1.00	1.09	0.07	.
Lakes	0.58	0.55	0.60	< 0.001	***
MidCentral	0.78	0.74	0.81	< 0.001	***
Nelson Marlborough	0.71	0.68	0.74	< 0.001	***
Northland	0.51	0.49	0.53	< 0.001	***

South Canterbury	0.65	0.61	0.69	< 0.001	***
Southern	0.71	0.69	0.74	< 0.001	***
Tairawhiti	1.02	0.96	1.09	0.54	.
Taranaki	0.58	0.55	0.61	< 0.001	***
Waikato	0.61	0.59	0.62	< 0.001	***
Wairarapa	0.65	0.60	0.69	< 0.001	***
Waitemata	0.77	0.75	0.80	< 0.001	***
West Coast	0.69	0.63	0.75	< 0.001	***
Whanganui	0.65	0.62	0.69	< 0.001	***
Not enrolled	0.65	0.60	0.69	< 0.001	***
Parent COVID-19 vaccination status					
2+ doses	*reference*				
1 dose	0.10	0.09	0.11	< 0.001	***
No doses	0.05	0.04	0.05	< 0.001	***
Has had COVID-19	1.12	1.10	1.14	< 0.001	***

Source: IDI and author analyses. Note: Profile likelihood confidence intervals are used which is based on the log-likelihood function. Logistic regression models drops observations with missing values; thus, these do not appear in the table.
[a] Middle Eastern, Latin American and African

DISCUSSION

Against a backdrop of suboptimal pediatric COVID-19 vaccine uptake in NZ, this population-level retrospective cohort study found that children with migrant backgrounds had higher uptake compared to non-migrant children. Logistic regression modeling was used to investigate the influence of factors that can influence vaccine uptake. All variables included in the model, namely ethnicity, gender, age, family type, household income, deprivation, PHO region, parent COVID-19 vaccination status, and the child's COVID-19 infection status significantly influenced COVID-19 vaccine uptake. Of the included factors, parents' COVID-19 vaccination status was the largest contributor. These findings have implications for equitable COVID-19 vaccine roll-out campaigns, particularly with addressing parental vaccine access and acceptance.

Two Canadian studies reported that the percentage of overseas-born parents who intended or reported COVID-19 vaccination for their children was lower than Canadian-born parents (Humble et al., 2022; McKinnon et al., 2021). On the contrary, this study shows significantly higher COVID-19 vaccination rates among children with migrant and refugee backgrounds, compared to non-migrant children. NZ-born migrant children had the highest COVID-19 vaccination rates (60.1%), followed by overseas-born migrant children (51.6%), both of which were higher than NZ-born non-migrant children (46.3%). This finding is supported by previous NZ research on routine childhood vaccine uptake in which NZ-born migrant children had the highest recorded age-appropriate vaccination rates compared to overseas-born migrant and NZ-born non-migrant children across all ethnicities (Charania et al., 2018). It is important to note that the composition of children in each cohort may have influenced this finding. In our previous study (Charania et al., 2018) and the current study, many NZ-born migrant children were from the Asian region and identified as being Asian. NZ research has found that Asian parents have positive attitudes towards vaccinations (Pal et al., 2014). Similar to our previous study (Charania et al., 2018), this study showed that almost half (48.3%) of overseas-born migrant children were from Australia or NZ and over half (51.4%) did not require a visa to enter NZ. Parents of these children with these migrant backgrounds may have some familiarity with navigating services in NZ and thus, this may have influenced the finding that overseas-born migrant children were more likely to be vaccinated against COVID-19 compared to non-migrant children.

In this study, the largest contributing factor for paediatric COVID-19 vaccination was parental vaccination status, where children with fully vaccinated parents being significantly more likely to receive the COVID-19 vaccine compared to children whose parents were only partially vaccinated or unvaccinated. International evidence has shown a close link between parents' own COVID-19 vaccination status and their intentions to vaccinate their child for COVID-19 (Rane et al., 2022; Steletou et al., 2022; Suvada et al., 2022; Szilagyi et al., 2021; Teasdale et al., 2022). Several demographic and socio-economic factors were reported to be associated with parental vaccine hesitancy, including age, ethnicity, gender, education level, previous COVID-19 infection, and their child's age (McKinnon et al., 2021; Rane et al., 2022; Steletou et al., 2022; Suvada et al., 2022; Szilagyi et al., 2021; Teasdale et al., 2022). Protecting their child and family from COVID-19, preventing disease spread, and wanting to return to normal life were among the top reasons for parents who intended to vaccinate their child (Humble et al., 2022). Common reasons among parents who did not intend to vaccinate their child were concerns about the short length of clinical trials, speed of vaccine development, it being a new vaccine, vaccine side effects, vaccine safety, and vaccine efficacy (Humble et al., 2022; McKinnon et al., 2021; Rane et al., 2022; Steletou et al., 2022; Szilagyi et al., 2021; Teasdale et al., 2022). Parents elaborated that their concerns about COVID-19 vaccine safety and efficacy included possible long-term effects and perceived misinformation about the benefits and risks of vaccination in children (Humble et al., 2022).

This study also found clear ethnic, age, household income, deprivation, and regional differences in uptake of the paediatric COVID-19 vaccination. Similar to previous research, older children were more likely to receive a COVID-19 dose compared to younger children (Humble et al., 2022; McKinnon et al., 2021; Szilagyi et al., 2021). Language barriers can contribute to immunisation inequities among migrant and refugee populations (Charania et al., 2019). However, in our study, earlier models explored the influence of language and found that this was largely insignificant. That is, English proficiency neither increased nor decreased the likelihood of children being vaccinated for COVID-19. Previous literature found that having language-specific vaccination information would increase parents' likelihood of vaccinating their children for COVID-19 (Humble et al., 2022). NZ's approach to communications during the pandemic was inclusive in nature, with news briefings being made available in English and New Zealand Sign Language, and vaccine resources available in several languages, which may have supported migrant parents to vaccinate their children (Beattie & Priestley, 2021; Ministry of Health, 2022d).

Asian children were significantly more likely to be vaccinated for COVID-19, while Māori, Pacific and MELAA children were less likely to be vaccinated, compared to European children. This is consistent with the literature related to the socio-economic and ethnic disparities in the access and uptake of non-COVID-19 childhood immunisations. As noted above, Asian parents displayed positive immunisation attitudes, were aware of the value of immunisations, accepted government encouragement to use immunisations services, and perceived minimal barriers to accessing immunisations (Pal et al., 2014). In contrast, while Māori Māmā are supportive of routine childhood vaccines, they were opposed to the coercive actions used to vaccinate their children and noted how institutional racism and bias in the current health system excluded Māori worldviews and practices (Brown et al., 2021). Among the Pacific population, various barriers to routine childhood immunisation exist related to deprivation, low health literacy, and limited access to culturally-appropriate services (Tafea et al., 2022).

Barriers to accessing COVID-19 vaccination services disproportionately impacted Māori and Pacific populations, and those who live in rural and high socio-economically deprived areas. Spatial accessibility to vaccination services varies across NZ, which has implications for equitable access to COVID-19 vaccines by ethnicity, age group, level of deprivation, and geographical region (Whitehead et al., 2022). In our study, children from more rural regions, such as Northland and Bay of Plenty, had lower uptake of the COVID-19 vaccination compared to children in Auckland, an urban setting. This finding is supported by a spatial

analysis of COVID-19 vaccination services in NZ that found that rural areas had worse access to vaccination services compared to urban areas (Whitehead et al., 2022). Moreover, the study found that those living in high socio-economic deprivation and areas with a high proportion of Māori and Pacific populations had statistically lower spatial access to vaccination services (Whitehead et al., 2022).

Implications for paediatric COVID-19 vaccination policies and practice

Despite the paediatric COVID-19 vaccine being publicly funded, coverage rates have been suboptimal. To increase uptake of the paediatric COVID-19 vaccine, efforts are needed to address parental vaccine hesitancy as parent's own perspectives and uptake of COVID-19 vaccinations plays a role in vaccinating their own children against COVID-19. Literature suggests the provision of clear, timely, and accurate information on the importance of vaccinating young children to help address parents' concerns (Humble et al., 2022; McKinnon et al., 2021; Rane et al., 2022; Steletou et al., 2022; Szilagyi et al., 2021; Teasdale et al., 2022). Public health communications need to account for vaccine-specific hesitancy associated with the novel COVID-19 vaccines and sufficiently address changes in vaccine recommendations as the pandemic evolves (Driedger et al., 2022). A systematic review noted that social media platforms are an important source of COVID-19 information among some migrant and ethnic minority populations (Goldsmith et al., 2022). Thus, appropriately tailored audio and visual messages to the demographics of the target population that use stories and case studies of severe disease to highlight the benefits of vaccination have been recommended (Steffens et al., 2022). Given the promise of mobile health applications (mHealth apps) to increase vaccine confidence and vaccination rates, an upcoming randomised, controlled trial will assess the effectiveness of a mHealth app to address the logistical and motivational barriers to paediatric COVID-19 vaccination among parents (McCulloh et al., 2022). Literature has also highlighted how their child's doctor was a trusted source of information and could influence non-intenders to vaccinate their children (Steletou et al., 2022; Szilagyi et al., 2021). For instance, a small Australian study noted that parents preferred that their child is vaccinated by a familiar and convenient general practice (Steffens et al., 2022).

Amidst mediocre paediatric COVID-19 vaccination rates, social inequities in vaccine access and acceptance exist. To ensure equitable access to COVID-19 vaccines, specific efforts are needed to address barriers to vaccine access and acceptance among marginalised populations, including Māori and Pacific, and rural and high deprivation areas with lower access. Tailoring localised interventions should involve active engagement with the target communities. For tamariki Māori, the paediatric COVID-19 vaccine rollout needs to uphold our obligations to Te Tiriti o Waitangi and based on a collective, rather than individual, risk-benefit analysis (Sinclair et al., 2021). Training community vaccine advocates, employing localised strategies to make vaccination convenient, and supporting vaccinators with vaccinating younger children are some additional recommendations to increase paediatric COVID-19 vaccination coverage rates (Steffens et al., 2022).

This study also revealed that coverage rates were highest for migrant children when compared to non-migrant children, which may be attributable to offering the vaccine free of charge no matter a child's immigration and citizenship status, and the ethnic-inclusive communications with clear and consistent messaging at the national level (Beattie & Priestley, 2021; Ministry of Health, 2022d, 2023). Literature calls for co-producing interventions with community members and organisation to help overcome commonly identified barriers and address vaccine hesitancy among migrants to accessing immunisation services (Charania et al., 2020; Crawshaw et al., 2021; Deal et al., 2021). This finding may also be attributable to where COVID-19 vaccination services were available. Studies in NZ and the US demonstrate the importance of the locations and options of vaccination services to improve coverage rates (DeCuir et al., 2022; Whitehead et al., 2022). The COVID-19 vaccine rollout in NZ used many vaccine delivery services, including

GP clinics, pharmacies, District Health Board-run dedicated vaccination centres, and iwi-led or run by Māori or Pacific providers (Whitehead et al., 2022).

To better understand which determinants influence migrant parents' uptake of COVID-19 vaccinations, future work should be undertaken in other settings. In NZ, the COVID-19 vaccine rollout campaign should be investigated to understand what aspects helped to improve uptake among migrant communities and areas for improvement as these learnings could be applicable to future immunisation programmes. Moreover, since parents' COVID-19 vaccination status influenced that of their children, future research is required to understand the factors influencing parents' decisions to vaccinate themselves.

Strengths and limitations

We have used the best-quality data available by leveraging NZ's unique data collection and linking capabilities within the IDI for this study. Using data for a national cohort of children enabled granular examination of differences in paediatric COVID-19 vaccination uptake by various socio-demographic characteristics with a focus on migration background. Some limitations should be considered when interpreting our study's findings. First, we have used existing administrative data for a different purpose than which it was originally designed to collect. Thus, we were not able to control the variables or the value categories within each variable thereby potentially introducing some inaccuracies. Second, the earliest visa held by the migrant child or their migrant parent was used and transitions through different visa categories was not examined.

CONCLUSION

Paediatric COVID-19 vaccination coverage rates are far from optimal, and varied by individual and household characteristics, including ethnicity, sex, age, family type, income, deprivation, and region. Importantly, children with migrant and refugee backgrounds were more likely to receive a COVID-19 vaccine compared to non-migrant children. Parental COVID-19 vaccination status was the strongest predictor of paediatric COVID-19 vaccination status. To improve equitable uptake, efforts must continue to support parents to make confident vaccine decisions and improve access using localised approaches that address logistical barriers, particularly among marginalised population sub-groups.

Contributors

NC and JP designed the study. LT linked and analysed the data. All authors contributed to the analysis plan and interpretation of the findings. NC and LT drafted the initial manuscript, and JP critically revised it for intellectual content. All authors gave final approval of the manuscript.

Declarations of interests

The authors have no potential conflict of interest to report.

Data Sharing

Summary Statistics New Zealand Security Statement

This study is based on the integration of anonymised population census data from Statistics New Zealand. The results on this manuscript and are not official statistics. They have been created for research purposes from the Integrated Data Infrastructure (IDI), managed by Statistics New Zealand. The opinions, findings, recommendations, and conclusions expressed on this website are those of the author(s), not Statistics NZ. This project was approved by Statistics New Zealand as a Data Laboratory project under the Microdata Access Protocols in 1997. The datasets created by the integration process are covered by the Statistics Act 1975 and can be used for statistical purposes

only. Only approved researchers who have signed Statistics New Zealand's declaration of secrecy can access the integrated data in the Data Laboratory. For further information about confidentiality matters in regard to this study please contact Statistics New Zealand.

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