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Human Vaccines & Immunotherapeutics

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/khvi20

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To cite this article: Nadia A. Charania, Linda Kirkpatrick, Janine Paynter & Nikki Turner (2023) Childhood vaccination uptake among children born in Aotearoa New Zealand based on parental nationality, Human Vaccines & Immunotherapeutics, 19:2, 2240688, DOI: 10.1080/21645515.2023.2240688

To link to this article: https://doi.org/10.1080/21645515.2023.2240688

HUMAN VACCINES & IMMUNOTHERAPEUTICS
2023, VOL. 19, NO. 2, 2240688
https://doi.org/10.1080/21645515.2023.2240688

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RESEARCH ARTICLE

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Childhood vaccination uptake among children born in Aotearoa New Zealand based on parental nationality

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ABSTRACT

Migrants and refugees generally experience immunization inequities compared to their host populations. Childhood vaccination coverage rates are influenced by a complex set of interrelated factors, including child and parental nativity. Coverage rates for MMR, pertussis, and HPV vaccines were compared among children born in Aotearoa New Zealand (NZ) of overseas-born parents or NZ-born parents. A nationwide retrospective cohort study was conducted using linked, de-identified data. Logistic regression models examined the most influential factors contributing to differences in timely vaccine uptake. Of the total study population who had received all scheduled vaccines ($N = 760,269$), 32.9% were children of migrant parents. Children of migrant parents had higher rates of complete and timely uptake for MMR, pertussis, and HPV vaccinations compared to non-migrant children. NZ-born children of migrant parents were significantly more likely to receive MMR and pertussis-containing vaccines on-time compared to those of non-migrants. All included factors, except for the child's gender and parents' English ability, significantly influenced vaccine uptake. Among NZ-born children of migrant parents, additional logistic modeling found significant differences based on parental duration of residence, visa group, and region of nationality. Findings point to the importance of differentiating between parent versus child nativity when examining immunization coverage. While vaccination rates were higher for NZ-born children of migrant parents, compared to non-migrant parents, timely coverage rates across both groups were below national targets. Continued efforts are needed to improve timely immunization service delivery to address suboptimal and inequitable coverage.

ARTICLE HISTORY
Received 28 April 2023
Revised 28 June 2023
Accepted 20 July 2023

KEYWORDS
Pediatric; immunization; vaccine; equity; child; data-linking; migrant; refugee; Aotearoa New Zealand; integrated data infrastructure

Introduction

Migration is at unprecedented levels – 281 million international migrants live outside their country of usual residence, representing 3.6% of the global population.[1] To protect against vaccine-preventable diseases (VPDs), it is imperative that children are age-appropriately vaccinated according to national immunization programs.[2] Globally, literature notes that migrants and refugees generally have lower immunization coverage and higher VPD burden compared to their host populations.[3] A complex myriad of factors influence these inequities, including nativity, country of origin, citizenship status, and language proficiency, to name a few.[3] Childhood vaccination is ultimately a parental decision, and previous research has shown that parental nativity is associated with their child being timely immunized.[3–8] For instance, an Australian study found differences in timely childhood vaccination by maternal nativity and region of birth.[5]

In Aotearoa New Zealand (NZ), all children under 18 years are eligible for publicly funded vaccines according to the National Immunisation Schedule (NIS), no matter their immigration or citizenship status.[2] Childhood immunization coverage rates have been suboptimal, and the current immunization coverage for 24-months old is 82.4%, well below the 92% target set by Manatū Hauora Ministry of Health.[9] Despite interventions to improve routine childhood immunization coverage and reduce equity gaps, there remain substantive immunization inequities by ethnicity and geographic region, which have become more pronounced since the COVID-19 pandemic.[9–12] Coverage among Māori (Indigenous people of NZ) has been persistently lower than other ethnic groups, reflecting barriers to vaccine access and acceptance and ongoing impacts of colonization and systemic racism.[9,10,13] Moreover, those living in more deprived regions of NZ have lower vaccination coverage compared to those living in less deprived regions in a step-wise manner, displaying a social gradient of health.[9] Evidence has noted that higher proportions of Māori live in the most deprived areas, indicating an association between ethnicity and deprivation.[14]

National coverage data can mask immunization inequities by migration background as this is not routinely reported on. Overseas-born migrants make up over a quarter of NZ's total population and represent a diverse range of nationalities and

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Supplemental data for this article can be accessed on the publisher's website at https://doi.org/10.1080/21645515.2023.2240688.

ethnicities.[15,16] Migrants can enter NZ by various pathways, primarily related to employment, education, and visiting purposes, and refugees can enter via quota, family reunification, asylum seeking, and community sponsorship pathways.[15–17] A national retrospective cohort study of children aged up to 5 years old found that less than half of overseas-born children were enrolled on the National Immunization Register (NIR) and had lower age-appropriate vaccination rates compared to children born in NZ.[4] While most children born in NZ were enrolled on the NIR, children born in NZ of migrant mothers had the highest recorded age-appropriate vaccination rates across most ethnic groups compared to NZ-born non-migrant children and overseas-born children.[4] These findings point to the importance of parent–child nativity in childhood vaccination uptake.[4]

It is important to further investigate timely childhood vaccination uptake by the migration background of parents and their children to understand differences in coverage to tailor immunization policies and programs. An analysis of coverage rates and determinants among overseas-born children has been presented separately given their different migration and resettlement journeys compared to NZ-born children with migrant backgrounds.[18] Thus, the presented study examined timely routine childhood vaccination coverage and associated factors among children born in NZ of either overseas-born parents (migrants) or NZ-born parents (non-migrants). This study extends previous NZ-based research[4] by focusing on children under 18 years of age to examine the uptake of vaccines given during early childhood and adolescence and using logistic regression models to investigate the most influential factors contributing to differences in complete and timely vaccine uptake.

Methods

This study is part of a larger multimethod study[19] that involved quantitative and qualitative studies to explore factors associated with immunization uptake among children with migrant and refugee backgrounds. Ethical approval to conduct this study was granted by the Auckland University of Technology Ethics Committee (18/322).

Participants

Three NIS vaccines were selected for this study: the measles, mumps and rubella (MMR) vaccine (two doses), pertussis-containing vaccines (three primary doses and two boosters), and the human papillomavirus (HPV) vaccine (at least two primary doses).[2] MMR and pertussis-containing vaccines were chosen as they protect against two of the most infectious diseases.[2] Uptake of the MMR vaccine is particularly important given the widespread misinformation, including the purported link with autism.[20] The HPV vaccine was chosen as migrant parents have reported misconceptions about the vaccine, including fear of encouraging sexual activity, and limited knowledge about the disease itself.[21] These vaccines were also chosen as they span across both early childhood and adolescence, and different settings in which the vaccines are administered.[2] MMR and the primary series of pertussis-containing vaccines are administered in general practice settings by family doctors and practice nurses. While as of 1 September 2008, the national HPV immunization program is primarily administered via school-based immunization programs with an initial catch-up program offered through schools and primary healthcare settings.[22]

Timely MMR, pertussis, and HPV vaccine uptake was examined among NZ-born children (under 18 years of age) of migrant parents compared to those of non-migrant parents as of December 2021.[a] The total study population included 847,197 children born in NZ, of which 31.9% had migrant parents. Children were excluded if they had opted out of the National Immunisation Register (NIR), were deceased, over 18, had moved permanently overseas, or had spent less than 6 months in NZ as of December 2021. All children were included for pertussis uptake; however, for MMR and HPV, 95.5% and 10.4% of the total study population was included, respectively.[b]

To examine timely vaccine uptake, the presented analysis included 760,269 children born in NZ who had received all scheduled vaccine doses (excluding partial or non-vaccinated), of which 32.9% had migrant parents.[c] To focus on timeliness, the analysis compared NZ-born children of migrant or non-migrant parents who were vaccinated on-time to those who were not. All children were included in the analysis of pertussis uptake. For MMR and HPV, 98.5% and 9.2% of the study population was included, respectively.[d]

Further analyses were undertaken among children of migrant and refugee parents ($N = 250{,}011$) to investigate the influence of additional parental migration factors, including duration of residence, visa category, and region of nationality. Similarly, all children were included in the pertussis uptake analysis, while only 96.3% were included for MMR and 7.8% for HPV.

Data collection and measures

Individual-level anonymized administrative data from Stats NZ's Integrated Data Infrastructure (IDI) was used to generate explanatory and outcome variables for this study. The IDI is a centralized collection of whole-population administrative datasets that spans several sectors such as health, social services, and education. Individuals who have interacted with government services are assigned a unique, confidential, and anonymized 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 prioritized ethnicity,[e] age, gender, and deprivation level; Department of Labour Decisions dataset for visa types; Ministry of Health National Enrolment Service dataset for regional enrollment in the health system; Ministry of Business, Innovation and Employment Border Movement and NZ Customs Journeys dataset for immigration and travel data (e.g., parent's nationality based on earliest arrival, time spent in NZ); Department of Internal Affairs for birth data; 2013 and 2018 Census for parent's highest qualification obtained, ability to speak English, family type, and household income.[f] Of primary interest was the Ministry of Health National Immunisation Register (NIR) that records each vaccination event for an individual.

The NIR was used to create a binary outcome measure equal to 1 if a child had received all scheduled vaccinations for which they were due on-time, and 0 if they were not received on-time. 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. Logistic regression models were used to estimate the likelihood of receiving all scheduled vaccinations on-time for MMR, pertussis, and HPV controlling for several explanatory variables captured in matrix $X_i^{'}$ in Equation (1).

$$logit(p_i|Received = 1) = \alpha + \beta_1 C_i + \beta_i^{'} X_i^{'} \gamma \quad (1)$$

With subscript i referring to individual $i = 1, \ldots, N$. Terms starting from the left-hand side:

- Where p_i measures the likelihood of individual i having received all scheduled MMR, pertussis, or HPV vaccinations for which they are due on-time (*where* $\Pr(y_i = 1)$) as of December 2021.
- C_i is a categorical cohort variable that measures which cohort a child belongs to, with NZ-born non-migrant children being the reference cohort.
- $X_i^{'}$ is a matrix of individual-level explanatory variables that includes (please refer to Tables 2 and 3 for descriptions of variables):
  - Gender (reference group Female)
  - Age group (reference group 6 to 14)[g]
  - Parent's highest education (reference group Bachelor's Degree)[h]
  - Parent's ability to speak English (reference group no English ability)[i]
  - Family income (reference group Low Income)
  - Family type (reference group Couple with children)
  - Deprivation (reference group Quintile 1)[j]
  - Primary Health Organisation (PHO) region (reference group Auckland)[k,23,24]

Timeliness for each vaccination was defined as:

- MMR first dose received by 15 months (before immunization schedule change) or by 12 months (after immunization schedule change) and second dose received between 15 and 54 months.
- Pertussis first, second, and third doses received between 1 and 6 months after birth, fourth dose received between 4 and 4.5 years old, and fifth dose received between 11 and 12 years old
- HPV first dose received after 11 years old, and second dose received before 14 years old by (female children only)

Additional logistic regressions were run for NZ-born children of migrant and refugee parents. All the variables are the same as in Equation (1), with the addition of the following:

- Parent's years since arrival to New Zealand as of January 2022 (reference group 10+ years)
- Parent's visa group (reference group No Visa)
- Parent's United Nation (UN) region (reference group Australia and New Zealand) [l]

Results: overview of vaccination status

Of the total study population ($N = 847{,}197$) approximately 270,000 were children of migrant parents and 577,000 were children of non-migrant parents. The two cohorts had similar age and sex distribution. However, because the cohorts were defined based on migration history, there were large differences in the ethnic composition of the two cohorts. About 9% of children of migrant parents were Māori compared to approximately 40% of children of non-migrant parents. In contrast, about 40% of children of migrant parents were Asian compared to only 3% of children of non-migrant parents. There were slightly more Pacific children of migrant parents (14%) compared to children of non-migrant parents (8%). Table 1 provides a descriptive overview of vaccination coverage for MMR, pertussis, and HPV among the total study population of NZ-born children of migrant and non-migrant parents. Suboptimal timely coverage rates were noted across both groups of children. Across the three vaccines of interest, NZ-born children of migrant parents had higher proportions of those who were fully vaccinated and had received their vaccinations on-time compared to those with non-migrant parents.

Results: MMR and pertussis

Of the total study population who had received all scheduled vaccines ($N = 760{,}269$), the proportion of children who were fully vaccinated for MMR on-time was higher among NZ-born children of migrant parents compared to those of non-migrant parents (Supplementary Table S1). Results from logistic modeling show that this difference is statistically significant (Table 2). Young children (aged 6 and under) were more likely to be vaccinated on-time compared to older children (aged between 6 and 14). Māori and Pacific children were significantly less likely to be vaccinated on-time for MMR compared to NZ European children, while Asian children were significantly more likely to be vaccinated for MMR on time. Moreover, children of couples and those with higher income and education were more likely to be vaccinated compared to their counterparts. Children who lived in more deprived areas were less likely to be vaccinated on-time compared to those in less deprived area. Regional differences were present; however, the magnitude of timeliness effects was not large. Similar results and patterns were noted for pertussis-containing vaccines (Supplementary Tables S2 and S3).

Among NZ-born children with migrant parents who had received all scheduled vaccines ($N = 250{,}011$), there were significant differences in timely MMR vaccination uptake by age group, ethnicity, household income, education, deprivation, and PHO region (Supplementary Table 4). Of interest to this

Table 1. MMR, pertussis, and HPV vaccine coverage rates by a cohort of children born in Aotearoa New Zealand ($N = 847,197$)*.

	Children of migrant parents		Children of non-migrant parents	
	n	%	n	%
MMR				
Received	240,837	94.1%	507,879	91.8%
Received and on time	*193,293*	*75.5%*	*352,983*	*63.8%*
Received and not on time	*47,544*	*18.6%*	*154,896*	*28.0%*
Partially vaccinated or did not receive	15,105	5.9%	45,366	8.2%
Total	**255,942**	**100.0%**	**553,245**	**100.0%**
Pertussis				
Received	250,008	92.6%	510,261	88.4%
Received and on time	*217,593*	*80.6%*	*393,855*	*68.2%*
Received and not on time	*32,415*	*12.0%*	*116,403*	*20.2%*
Partially vaccinated or did not receive	20,001	7.4%	66,819	11.6%
Total	**270,009**	**100.0%**	**577,080**	**100.0%**
HPV				
Received	19,494	83.8%	50,082	76.9%
Received and on time	*19,221*	*82.6%*	*49,229*	*75.7%*
Received and not on time	*273*	*1.2%*	*783*	*1.2%*
Partially vaccinated or did not receive	3,732	16.2%	14,934	23.1%
Total	**23,226**	**100.0%**	**65,100**	**100.0%**

Source: IDI and author analyses. Note: in order to meet privacy protection requirements of Stats NZ, counts have been randomly rounded to base 3.

*All children were included for pertussis uptake; however, for MMR and HPV, 95.5% and 10.4% of the total study population was included, respectively.

study, NZ-born children with migrant parents who arrived in NZ less than 10 years were more likely to be vaccinated on-time for MMR compared to those who arrived more than 10 years ago. Moreover, children of migrants who arrived on international humanitarian and refugee visas were significantly more likely to be vaccinated on-time for MMR compared to those who did not require a visa to enter NZ. Regarding parental UN region of nationality, children of parents from Asian and other Oceania regions (excluding reference group Australia and NZ) regions were more likely to be vaccinated compared to those who were Australian and NZ nationals. The findings were similar for pertussis-containing vaccines (Supplementary Table 5). For parental visa group, in addition to those that entered on international humanitarian and refugee visas, those on family and student visas were significantly more likely to be vaccinated on-time for pertussis compared to those who did not need a visa to enter NZ.

Results: HPV vaccine

The proportion of eligible children who were fully vaccinated for HPV on-time was high across both cohorts, with NZ-born children of migrant parents having a slightly higher proportion (98.6%) of timely coverage compared to those of non-migrants (98.4%) (Supplementary Table 6). Across both groups, the proportion of children fully vaccinated on-time was similar by the explored factors. Logistic regression modeling did not find a significant difference in HPV uptake between NZ-born children of migrant and non-migrant parents (Table 3). Children of Māori, Pacific, and Asian ethnicity were significantly more likely to be fully vaccinated on-time, compared to NZ European children. There were no differences between the likelihood of being fully vaccinated on time for children with one or two parents, household incomes, parent's education level, or English-speaking ability. In addition to some significant difference noted by the PHO region, children living in the most deprived areas were significantly more likely to be fully vaccinated on-time compared to children living in the least deprivation.

Among NZ-born children of migrant parents, there were significant differences noted by duration of residence (Supplementary Table 7). NZ-born children whose migrant parents had been in NZ for less than 10 years were significantly less likely [odds ratio (OR) 0.68, confidence interval (CI) 0.48–0.98 for less than 5 years; OR 0.70, CI 0.53–0.94 for 5–10 years] to be fully vaccinated for HPV on-time, compared to children whose parents had been in NZ for more than 10 years, after adjusting for the other included variables. Children whose parents arrived in NZ on family, international humanitarian, Pacific humanitarian, refugee, student, visitor, and work visas were significantly more likely to be vaccinated for HPV on-time compared to children whose parents did not require a visa to enter NZ. Children whose parents' nationality was Asian (except for central and western Asian regions) and Micronesia and Melanesia regions were significantly more likely to be fully vaccinated for HPV compared to children whose parents were Australian and NZ nationals.

Discussion

This population-level retrospective study found that NZ-born children of migrant parents were significantly more likely to receive MMR and pertussis-containing vaccines on-time compared to non-migrant children. No difference was found between both groups for HPV. Across both groups of children, all the included factors in the logistic regression models, except for the child's gender and parents' ability to converse in English, contributed to differences although slight differences by vaccine of interest were noted. To explore the reasons for these cohort differences, further analyses were conducted among NZ-born children of migrant parents and found significant differences based on parental migration factors

Table 2. Multivariable logistic regression for complete and timely MMR vaccination among NZ-born children of migrant and non-migrant parents who had received all schedules vaccines.

	Odds Ratio	95% CI		*P*-value	Sig.
Cohort					
NZ-born children of migrant parents	1.08	1.06	1.09	<.001	***
NZ-born children of non-migrant parents	*reference*				
Age group					
0 < 2	1.39	1.34	1.45	<.001	***
2 < 6	1.59	1.56	1.62	<.001	***
6 < 14	*reference*				
14 < 19	0.49	0.48	0.50	<.001	***
Gender					
Female	*reference*				
Male	0.98	0.97	0.99	<.001	***
Ethnicity					
Māori	0.57	0.56	0.58	<.001	***
Pacific	0.71	0.69	0.72	<.001	***
Asian	1.89	1.84	1.94	<.001	***
MELAA[a]	1.16	1.09	1.22	<.001	***
Other	1.02	0.94	1.12	.63	
European	*reference*				
Family type					
Couple with children	*reference*				
One parent with children	0.82	0.80	0.83	<.001	***
Household income					
High	1.34	1.32	1.37	<.001	***
Medium	1.16	1.14	1.18	<.001	***
Low	*reference*				
Parent's highest education					
No Qualification	0.75	0.73	0.76	<.001	***
Level 1–6 Certificate/Diploma	0.86	0.85	0.88	<.001	***
Bachelors	*reference*				
Postgraduate	1.11	1.09	1.14	<.001	***
Overseas Secondary	1.00	0.97	1.04	.94	
Parent's ability to speak English					
No	*reference*				
Yes	0.95	0.88	1.03	.23	
Deprivation					
Quintile 1 (Lowest)	*reference*				
Quintile 2	0.98	0.96	1.00	.06	
Quintile 3	0.99	0.97	1.01	.39	
Quintile 4	0.94	0.92	0.96	<.001	***
Quintile 5 (Highest)	0.83	0.81	0.84	<.001	***
PHO Region					
Auckland	*reference*				
Bay of Plenty	0.75	0.72	0.78	<.001	***
Canterbury	1.30	1.27	1.34	<.001	***
Capital and Coast	1.16	1.12	1.20	<.001	***
Counties Manukau	0.97	0.95	1.00	.04	*
Hawkes Bay	0.97	0.93	1.00	.08	
Hutt Valley	1.24	1.19	1.29	<.001	***
Lakes	0.97	0.93	1.01	.14	
MidCentral	0.91	0.88	0.94	<.001	***
Nelson Marlborough	1.34	1.28	1.39	<.001	***
Northland	0.84	0.81	0.87	<.001	***
South Canterbury	1.24	1.17	1.32	<.001	***
Southern	1.32	1.28	1.36	<.001	***
Tairawhiti	0.76	0.73	0.80	<.001	***
Taranaki	1.03	0.99	1.07	.15	
Waikato	0.80	0.78	0.82	<.001	***
Wairarapa	1.42	1.34	1.51	<.001	***
Waitemata	0.83	0.81	0.85	<.001	***
West Coast	1.28	1.19	1.38	<.001	***
Whanganui	0.98	0.94	1.02	.37	
Not enrolled	0.98	0.95	1.02	.35	

Source: IDI and author analyses. Note: Profile likelihood confidence intervals are used which is based on the log-likelihood function. Observations with missing values are dropped in a logistic regression and hence 'Unknown' categories do not appear in the table.
[a]Middle Eastern, Latin American, and African.

including duration of residence, visa group, and region of nationality.

Literature presents a mixed picture of the direction of influence of parental nativity on childhood vaccine uptake.[4–8] Previous NZ-based research also found that NZ-born children of migrant parents had higher routine vaccination rates across most ethnic groups compared to children of non-migrant parents.[4] An Australian study reported that timely diphtheria-tetanus-pertussis dose 3 (DTP3) coverage among children Australian-born mothers was 76.2%, while

Table 3. Multivariable logistic regression for complete and timely HPV vaccination among NZ-born children of migrant and non-migrant parents who had received all schedules vaccines.

	Odds Ratio	95% CI		*P*-value	Sig.
Cohort					
NZ-born children of migrant parents	1.10	0.93	1.30	.23	
NZ-born children of non-migrant parents	*reference*				
Ethnicity					
Māori	1.58	1.33	1.90	<.001	***
Pacific	2.09	1.53	2.92	<.001	***
Asian	1.85	1.41	2.48	<.001	***
MELAA[a]	1.31	0.69	2.92	.45	
Other	0.46	0.25	0.92	.02	*
European	*reference*				
Family type					
Couple with children	*reference*				
One parent with children	0.97	0.80	1.18	.76	
Household income					
High	0.98	0.74	1.27	.86	
Medium	0.94	0.73	1.20	.60	
Low	*reference*				
Parent's highest education					
No Qualification	1.00	0.78	1.28	.99	
Level 1–6 Certificate/Diploma	1.15	0.97	1.36	.12	
Bachelors	*reference*				
Postgraduate	1.08	0.88	1.34	.46	
Overseas Secondary	0.95	0.88	1.34	.46	
Parent's ability to speak English					
No	*reference*				
Yes	1.59	0.67	3.20	.24	
Deprivation					
Quintile 1 (Lowest)	*reference*				
Quintile 2	1.03	0.86	1.24	.77	
Quintile 3	1.05	0.86	1.27	.64	
Quintile 4	1.24	1.00	1.54	.05	
Quintile 5 (Highest)	1.32	1.04	1.69	.02	*
PHO Region					
Auckland	*reference*				
Bay of Plenty	0.68	0.46	1.03	.07	
Canterbury	1.12	0.82	1.52	.46	
Capital and Coast	0.84	0.60	1.18	.31	
Counties Manukau	1.18	0.84	1.64	.34	
Hawkes Bay	0.98	0.64	1.52	.92	
Hutt Valley	1.08	0.70	1.71	.73	
Lakes	0.89	0.56	1.45	.62	
MidCentral	1.69	1.05	2.82	.04	*
Nelson Marlborough	1.00	0.65	1.57	.99	
Northland	1.10	0.69	1.80	.69	
South Canterbury	0.75	0.45	1.30	.28	
Southern	0.96	0.69	1.33	.82	
Tairawhiti	1.28	0.66	2.79	.49	
Taranaki	0.88	0.57	1.39	.58	
Waikato	1.73	1.20	2.50	<.001	**
Wairarapa	1.11	0.65	2.05	.71	
Waitemata	0.85	0.63	1.14	.30	
West Coast	0.64	0.38	1.14	.11	
Whanganui	1.24	0.73	2.24	.46	
Not enrolled	0.70	0.15	12.56	.73	

Source: IDI and author analyses. Note: Profile likelihood confidence intervals are used which is based on the log-likelihood function. Observations with missing values are dropped in a logistic regression and hence 'Unknown' categories do not appear in the table.
[a]Middle Eastern, Latin American, and African.

those of migrant mothers ranged from 66.8% to 79.9% depending on their region of birth.[5] In contrast, a US study found that children with an overseas-born mother were associated with 14% reduced odds of complete and timely vaccination compared to children with US-born mothers.[6]

This study found notable immunization inequities by ethnicity and region, but these differed for early childhood versus adolescent vaccines, which may relate to the setting within which immunizations are delivered. For MMR and pertussis-containing vaccines, for both groups, Māori and Pacific children were significantly less likely to be vaccinated on-time compared to NZ European children, which supports previous findings.[9,10,25,26] Research has pointed toward numerous barriers to vaccine access and acceptance experienced by Māori and Pacific families.[10,13,27] On the other hand, Asian children were significantly more likely to be vaccinated on-time for MMR and pertussis compared to NZ European children. This finding may be attributable to factors that support immunization among Asian parents, including pro-immunization views and perceiving minimal barriers to accessing vaccines.[28,29] Similar to national coverage rates,[9] across both groups, children living in

the highest deprivation areas were significantly less likely to be vaccinated on time for MMR and pertussis compared to those living in the lowest deprivation area. Regional differences found in this study generally mirror those reported by the Ministry of Health,[9] noting particularly low coverage in rural areas such as the Bay of Plenty and the Northland.

On the contrary, for the HPV vaccine, across both groups, Māori, Pacific, and Asian children had significantly higher coverage compared to NZ European children. Also, girls living in the highest deprivation areas had significantly higher timely HPV coverage compared to those living in the lowest deprivation area. The differences in HPV coverage by PHO region differed and were less varied compared to those seen for MMR and pertussis-containing vaccines. Previous research in Auckland also noted that the highest HPV coverage rates were among Pacific (88%), Asian (79%), and Māori (78%) girls compared to NZ Europeans (63%).[22] Moreover, the study also showed that school decile, a measure of socio-economic status, was significantly associated with HPV coverage; uptake was lowest among girls who attended decile 10 schools, which have the greatest proportions of students from high socio-economic backgrounds.[22]

Further evidence to support how the HPV school-based immunization program can help address individual and family-level barriers to vaccination is that a child's family type and household income were not significantly associated with receiving HPV vaccines on-time; whereas, this was the case for MMR and pertussis-containing vaccines that are delivered in general practice settings. Moreover, a review of literature worldwide found that despite confounders, there was a strong correlation between maternal education and child vaccination completion and that uptake increased in a stepwise manner with maternal education from none to tertiary level.[30] In this study, this trend was observed for MMR and pertussis-containing vaccines, but not for HPV. Thus, the setting within which immunizations are delivered appeared to play a role in vaccination uptake. School-based immunization programs for adolescents appear to be an effective approach to reach immunization targets and reverse long-standing disparities faced by non-European ethnic groups and those living in high deprivation and/or rural areas.[22] Previous NZ-based research found that NZ Europeans were more likely to be vaccinated in general practice.[22] Thus, offering a mix of immunization delivery options (school-based and general practice) appears to support the uptake of HPV vaccines.[22]

Factors associated with vaccine uptake among children of migrant parents

Migrant populations can face many barriers to vaccination, including language and communication challenges.[3] When exploring HPV uptake rates by parents' ability to speak English, children of those able to converse in English were less likely to be vaccinated on-time for HPV. However, the modeling showed parents' ability to converse in English was generally not a significant factor for timely vaccine uptake of MMR and pertussis.

Similar to previous research, differences in vaccine uptake were noted by parental nativity in the presented study.[5,8] However, it is difficult to make conclusions as each study used different variables (e.g., country of birth vs nationality) and grouped regions slightly differently. In this study, for all vaccines of interest, children with migrant parents of Asian nationality were significantly more likely to be vaccinated compared to Australian and NZ nationals. This finding supports the ethnic differences noted above. Similarly, an Australian study found significantly higher coverage rates among children of mothers from Asia, compared to children of Australian-born mothers.[5] The presented study also found that children with parents from African and parts of the Americas and European regions had lower proportions of being vaccinated. Similarly, compared to children of Australian-born mothers, children of mothers from Americas, Europe and former USSR, and Oceania regions had significantly lower coverage rates.[5] A US study also found that compared to children of US-born parents, children of Ukrainian-born and Russian-born parents were less likely to be immunized.[8]

Furthermore, slight variations in vaccination coverage by parental visa category were noted. These results are interesting as all children are entitled to publicly funded NIS vaccines regardless of their visa status. Across all vaccines of interest, children of parents who entered NZ via international humanitarian and refugee pathways were more likely to be age-appropriately vaccinated. This finding likely reflects differences in support offered to refugees and those with refugee-like backgrounds to engage with primary care services during their resettlement journey.

Implications for immunization policy and practice and future work

Among children born in NZ, children with migrant parents had higher coverage rates compared to children of non-migrant parents. As NZ-born children of migrant parents do not seem to experience the same immunization inequities observed among overseas-born children,[4,18] it appears to be important to differentiate between parent versus child nativity. Children born in NZ are given their unique National Health Index (NHI) number at birth, enrolled on the NIR (unless their parents opt off), and entitled to publicly funded health-care services. Compared to overseas-born children, this infers a level of engagement with health services that supports attending immunization events.

Given that childhood vaccination is a parental decision, it may be that immunization services are addressing some of the common vaccine barriers among migrants.[3] Indeed, as more recent arrival was associated with higher MMR and pertussis-containing vaccination coverage, it may be that the concerted efforts over the last two decades to improve immunization service delivery are supporting uptake among migrant background families.[11] However, some of the barriers identified in literature did not significantly influence uptake in our study population (e.g., language), and/or some of the other influencing factors were not adequately captured in our model. As timely coverage rates were still below the national targets among children of migrant parents, immunization providers should continue to develop and implement interventions to

address migrants' specific needs and access barriers.[31] Moreover, while some research points to a simple decision-making process in which migrant and refugee mothers expressed a lack of personal choice and followed providers' recommendations, more research and resources are required to support informed migrant parents' vaccine decision-making.[29,32]

Among NZ-born children of migrant parents, there are immunization inequities, particularly by duration of residence, visa category (and associated entitlements to publicly funded health services), and parental nationality. Differences among migrant sub-groups may reflect varying ethno-cultural and country-specific immunization beliefs and practices between migrant and non-migrant parents, and also among migrant parents themselves.[5,7,8] The coverage differences may also reflect the influence of other factors related to migration journeys, such as socio-economic status and healthcare utilization, which requires further investigation.[5–7]

Study strengths and limitations

The employed methods leveraged the best-quality data available because of NZ's unique data collection and linking capabilities within the IDI. Using data for a national cohort of children enabled granular examination of differences in childhood vaccination uptake by various socio-demographic characteristics with a focus on migration background. Some limitations should be considered when interpreting the study's findings. First, the study used existing administrative data for a different purpose than which it was originally designed to collect. Some inaccuracies may have been introduced since it was not possible to control the variables or the value categories within each variable. Second, the earliest visa held by the migrant parent was used, and transitions through different visa categories were not examined.

Conclusion

Among children born in NZ, those with migrant parents had higher rates of complete and timely vaccination uptake compared to non-migrant children. This suggests the importance of parent versus child nativity when examining immunization coverage. Furthermore, coverage among NZ-born children of migrant parents varied by parental duration of residence, visa category, and nationality. Efforts must continue to address the specific needs of migrant parents to support vaccine access and acceptance, particularly in general practice settings. School-based immunization programs appear an effective approach to reach immunization targets and address social inequities in vaccine access and acceptance for adolescents.

Notes

[a] Most recent data from the National Immunisation Register at the time of analysis.

[b] Children were included in the respective samples if they were due to receive at least one HPV, MMR, or pertussis vaccination. For MMR, this included children aged 12 months and above (if they were born after December 2019 when the National Immunisation Schedule changed for MMR) or 15 months and above (if they were born before December 2019). For pertussis, this included children aged 4 weeks old and above. Note that children who have received at least one dose of MMR or pertussis-containing vaccination, but not yet due for subsequent vaccinations, were counted as fully vaccinated. For HPV, this included female children aged 11 years and above. From 2008, the HPV vaccine was funded for female children initially and only funded for boys and young men from 2017 onwards.

[c] Only includes children who had received all scheduled vaccinations for which they were due. Children who were not fully or only partially vaccinated were excluded from the analysis.

[d] Children were included in the respective samples if they were due to receive at least one HPV, MMR, or pertussis vaccination. For MMR, this included children aged 12 months and above (if they were born after December 2019 when the National Immunisation Schedule changed for MMR) or 15 months and above (if they were born before December 2019). For pertussis, this included children aged 4 weeks old and above. Note that children who have received at least one dose of MMR or pertussis-containing vaccination, but not yet due for subsequent vaccinations, were counted as fully vaccinated. For HPV, this included female children aged 11 years and above. From 2008, the HPV vaccine was funded for female children initially and only funded for boys and young men from 2017 onwards.

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

[f] The 2018 Census variables for family type and household income was available for approximately 65% of the total sample. 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 exists, else proxy variable. Imputation accounted for approximately 30% 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.

[g] Excluded from HPV analysis.

[h] If exists in order of mother's education from the 2018 Census, father's education from the 2018 Census, mother's education from the 2013 Census, father's education from the 2013 Census.

[i] If exists in order of: mother's English ability from the 2018 Census, father's English ability from the 2018 Census, mother's English ability from the 2013 Census, father's English ability from the 2013 Census.

[j] 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.

[k] 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.

[l] The United Nations geographic grouping was used to define geographic regions.

Acknowledgments

This study was conducted in collaboration with Statistics New Zealand and within the confines of the Statistics Act 1975. We would like to thank members of The Monarch Collaboration (http://monarchcollaboration.org/) for their support of this study.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by a grant from the Health Research Council of New Zealand (18/586). The authors are solely responsible for final content and interpretation. The authors received no financial support or other form of compensation related to the development of the manuscript.

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NC applied for funding and designed the study with JP and NT. LK linked and analyzed the data. All authors contributed to the analysis plan and interpretation of the findings. NC and LK drafted the initial manuscript, and JP and NT critically revised it for intellectual content. All authors gave final approval of the manuscript.

Data sharing

Summary Statistics New Zealand Security Statement

This study is based on the integration of anonymized 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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