



ORIGINAL ARTICLE

Primary care practice and health professional determinants of immunisation coverage

Cameron C Grant,^{2,6} Helen Petousis-Harris,¹ Nikki Turner,¹ Felicity Goodyear-Smith,³ Ngaire Kerse,³ Rhys Jones,⁴ Deon York,¹ Natalie Desmond¹ and Joanna Stewart⁵

¹Immunisation Advisory Centre, ²Paediatrics, ³General Practice and Primary Health Care, ⁴Te Kupenga Hauora Māori, ⁵Biostatistics and Epidemiology, The University of Auckland and ⁶General Paediatrics, Starship Children's Hospital, Auckland District Health Board, Auckland, New Zealand

Aim: To identify primary care factors associated with immunisation coverage.

Methods: A survey during 2005–2006 of a random sample of New Zealand primary care practices, with over-sampling of practices serving indigenous children. An immunisation audit was conducted for children registered at each practice. Practice characteristics and the knowledge and attitudes of doctors, nurses and caregivers were measured. Practice immunisation coverage was defined as the percentage of registered children from 6 weeks to 23 months old at each practice who were fully immunised for age. Associations of practice, doctor, nurse and caregiver factors with practice immunisation coverage were determined using multiple regression analyses.

Results: One hundred and twenty-four (61%) of 205 eligible practices were recruited. A median (25th–75th centile) of 71% (57–77%) of registered children at each practice was fully immunised. In multivariate analyses, immunisation coverage was higher at practices with no staff shortages (median practice coverage 76% vs 67%, $P = 0.004$) and where doctors were confident in their immunisation knowledge (72% vs 67%, $P = 0.005$). Coverage was lower if the children's parents had received information antenatally, which discouraged immunisation (67% vs 73%, $P = 0.008$). Coverage decreased as socio-economic deprivation of the registered population increased ($P < 0.001$) and as the children's age ($P = 0.001$) and registration age ($P = 0.02$) increased.

Conclusions: Higher immunisation coverage is achieved by practices that establish an early relationship with the family and that are adequately resourced with stable and confident staff. Immunisation promotion should begin antenatally.

Key words: health personnel; immunisation schedule; primary health care; vaccination/ut (utilisation).

What is already known on this topic

- 1 Immunisation coverage is mediocre in New Zealand.
- 2 Until now, the majority of the research that has sought to explain this mediocre coverage has concentrated on family and household factors.
- 3 As immunisations are delivered by general practices, variability in the characteristics of these practices or of the health professionals that work there might be an important determinant of how well a practice delivers immunisation.

What this study adds

- 1 There is wide variability in the immunisation coverage achieved by general practices in New Zealand.
- 2 Socio-economic factors have a pervasive effect on immunisation coverage that is not explained by other practice or practitioner characteristics.
- 3 Better immunisation coverage is achieved by practices that establish an early relationship with the family and that are adequately resourced with stable and confident staff who place a priority on the delivery of quality immunisation services.
- 4 As most decision-making about immunisation occurs prior to the child's birth, the antenatal period is an opportunity for immunisation promotion.

Correspondence: Dr Cameron Grant, Department of Paediatrics, Faculty of Medicine and Health Sciences, University of Auckland, Private Bag 92019, Auckland, New Zealand. Fax: +011 649 373 7486; email: cc.grant@auckland.ac.nz

Description of potential conflicts of interest: Cameron Grant completed a consultancy on rotavirus gastroenteritis for GlaxoSmithKline during 2005 and 2006. Helen Petousis-Harris, Nikki Turner, Felicity Goodyear-Smith, Ngaire Kerse, Rhys Jones, Deon York, Natalie Desmond and Joanna Stewart have no potential conflicts of interests to declare.

Sources of funding and support: This project was funded predominantly by the Health Research Council and the Ministry of Health Immunisation Research Strategy through the Health Research Council of New Zealand Partnership Programme. The project was also supported by two smaller grants (each for less than 10% of the project budget) received from GlaxoSmithKline and the Royal New Zealand College of General Practitioners.

The Immunisation Research Strategy funded the employment of staff necessary to recruit participants, collect, manage, analyse and report the data. The GlaxoSmithKline grant was used to pay staff involved in data collection. The Royal New Zealand College of General Practitioners grant was used to recompense enrolled practices for their time.

Accepted for publication 20 September 2010.

Childhood immunisation is one of the most cost-effective preventive services.¹ Despite this, many countries do not achieve coverage sufficient to obtain the maximum population health benefits that immunisation can provide. New Zealand (NZ) is one such country. A 2005 national survey showed that only 77% of 2-year-old children had received all scheduled immunisations.² Large socio-economic and ethnic disparities exist with children from lower socio-economic status backgrounds and from NZ's indigenous (Māori) population having lower immunisation coverage.^{3,4}

NZ's poor immunisation performance is a long-standing issue. Surveys in 1992 and 1996 showed that between 60 and 70% of 2-year-old children were fully immunised, with lower coverage rates reported for Māori children.^{2,5,6} During these decades, research seeking to explain incomplete immunisation emphasised the characteristics of the child, family and household,⁵⁻⁷ and some attention to the role of knowledge and attitudes of health-care professionals.⁸ In contrast, there has been less investigation of the health system and professional contributions to immunisation completeness.

Identification and elimination of health system and professional barriers has been central to improvements in coverage in Australia and the USA in recent decades.⁹⁻¹²

NZ primary care system is a mixed model of central government funding with part patient co-payment for general practice services. Immunisation delivery for all the schedule vaccines is free. There is near universal enrolment (registration) for all children in primary care.

The aim of this study was to determine the primary care practice and health professional characteristics associated with higher immunisation coverage in NZ.

Methods

Study design and setting

We conducted a survey of primary care practices in the Auckland and Midland regions of NZ. Approximately 50% of NZ children aged 0-4 years reside in these regions.¹³ Ethical approval was obtained from the Ministry of Health Regional Ethics Committee.

Study sample

We recruited a random sample of practices with stratification by region and, in view of the specific concerns with low immunisation coverage for indigenous children, an over-sampling of Māori governance practices (independent Māori health providers that target services primarily towards Māori and have a Māori management and governance structure).¹⁴ There were 11 such practices in Auckland and 50 in Midland.

We aimed to enrol 125 practices. This number was sufficient to yield 80% power to show statistical significance at the 5% level for a practice or health professional characteristic associated with higher coverage if this characteristic was present in 20-25% more of the practices with higher coverage. These calculations assumed the characteristic being examined had a frequency between 10 and 70%.¹⁵

Data collection and measurements

Once informed consent was obtained from each recruited practice, we completed an audit of the immunisation records of all children from 6 weeks to 23 months old. Data that described immunisations received by each registered child and the child's age, age at registration and ethnicity were abstracted.

Practice characteristics, funding, co-payments, and immunisation recall and outreach used were described by interviewing a senior practice staff member. The socio-economic status of the registered practice population was measured using the NZ Index of Social Deprivation.¹⁶ This measure uses census data that describe household income and ownership, household member employment and education, and household amenities and crowding.

We selected at random one doctor and one nurse per practice and invited them to complete a computer-assisted telephone interview. This interview explored their experience, immunisation knowledge and attitudes, perceived barriers to immunisation, sources of information and perceptions of practice teamwork. Health professional knowledge and attitudes about immunisation were measured using a questionnaire developed in the UK and adapted for NZ use.¹⁷⁻¹⁹

We identified a random sample of caregivers of children registered at each practice. Using a randomly ordered list of the registered children, the practice receptionist contacted the caregivers of these children, aiming for a sample of 10 children per practice. Following informed consent, caregiver access to and satisfaction with the practice was measured using the General Practice Assessment Survey administered via a computer-assisted telephone interview.^{20,21} Their type of lead maternity provider and their immunisation knowledge and attitudes were also determined. Caregiver responses were aggregated by practice and were expressed as the median or predominant response per practice.

Data analysis

Immunisation coverage was defined using the third dose assumption. If the third in a series of vaccine doses was recorded as given, then it was assumed that the previous doses had also been given, whether or not they were recorded.²² This assumption results in a small overestimate of coverage that is less than the underestimate, which occurs if only recorded doses are counted.²²

Only data from children registered at each practice were included in the analysis. The proportion of children registered at each practice who had received their scheduled immunisations was described. The proportion immunised was transformed to facilitate analysis using the arcsin of the square root of the variable. This transformation made the variance constant across the distribution of coverage at each practice. We examined for interaction with either region or practice governance for any of the variables associated with coverage. Variables for which such interaction was present were not included in the statistical models.

A general linear model was created with the arcsin of the square root of the proportion immunised as the outcome variable. For the regression analyses, a base model was created,

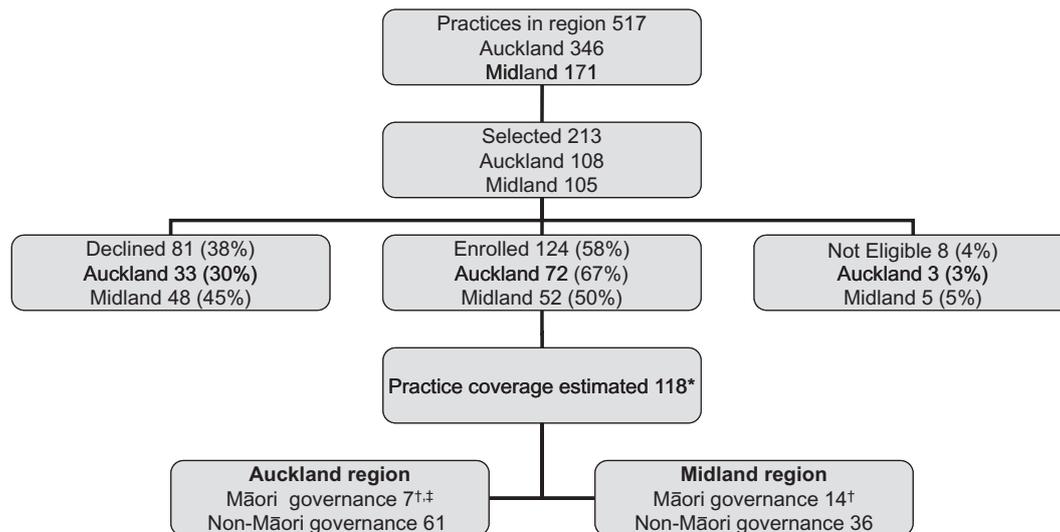


Fig. 1 Summary of practice recruitment and enrolment. *At one practice, none of the immunised children were registered. †Coverage for four Auckland and three Midland Māori governance practices was estimated as one practice. ‡One Auckland Māori governance practice was not eligible.

which included region, practice governance, socio-economic deprivation, and the age and age at registration of the children as explanatory variables. Explanatory variables that described practice characteristics, doctors, nurses and caregivers were added to this model. Multiple regression analyses were performed for each of these four areas and then a summary analysis that combined variables from all four areas.

Results

Practice recruitment (Fig. 1)

There were 517 practices in the study region. Two hundred thirteen (41%) were randomly selected, 108 in Auckland and 105 in Midland. A small number of practices were ineligible, mainly because they did not provide care for children. Practices were recruited between April 2005 and October 2006.

Of the 124 consenting practices, 112 were matched with NZ practices listed by the Ministry of Health. Of the 112 practices, 47 (42%) had access funding. A practice is eligible for access funding if 50% or more of registered patients are from high-deprivation communities and/or of Māori or Pacific ethnicities. Such funding increases the payments to the practice, which usually results in lower patient out-of-pocket fees.²³

Thirty-eight per cent of selected practices declined to participate. In Auckland, 0% of the selected Māori governance and 36% of the non-Māori governance practices declined; in Midland, 48% of the Māori governance and 51% of the non-Māori governance practices declined. The proportion of selected practices that declined varied by region ($P = 0.006$) but not by Māori governance ($P = 0.21$).

The proportion of practices with access funding did not differ with recruitment (recruited 42% vs not recruited 43%, $P = 0.91$). Compared with all NZ primary care practices, a larger proportion of the recruited practices had access funding (42% vs 28%).

Immunisation data were available for 124 practices, practice characteristics for 122, doctor data for 111, nurse data for 114 and caregiver data for 109. In Auckland, four practices were under the governance of one Māori health provider, and in Midland, three practices were under the governance of another Māori health provider. The immunisation databases for these two providers were not separable by practice and thus were treated as a single practice. At one small practice, none of the immunised children were registered, and hence the data from this practice were not included in the analysis. Therefore, the denominator for coverage estimates was 118 practices.

Demographics of the children

The median number of children from 6 weeks to 23 months old registered at each practice was 116 (62–193). A median of 75% (64–88) of the children aged 6–23 months who had been seen was registered at each practice. The non-registered children included those who were casual patients, were visiting from elsewhere or were in the process of having their registration transferred from another practice.

Immunisation coverage (Fig. 2)

A median of 71% (57–77%) of registered children at each practice were completely immunised. There was a wide and negatively skewed distribution of practice immunisation coverage. Practice immunisation coverage varied by practice governance (Māori 56% vs non-Māori governance 73%, $P < 0.001$) and by region (Auckland 68% vs Midland 73%, $P = 0.02$).

Socio-economic deprivation, ethnicity and practice demographics (Table 1)

Practice immunisation coverage decreased as the proportion of the practice population in the most socio-economically deprived

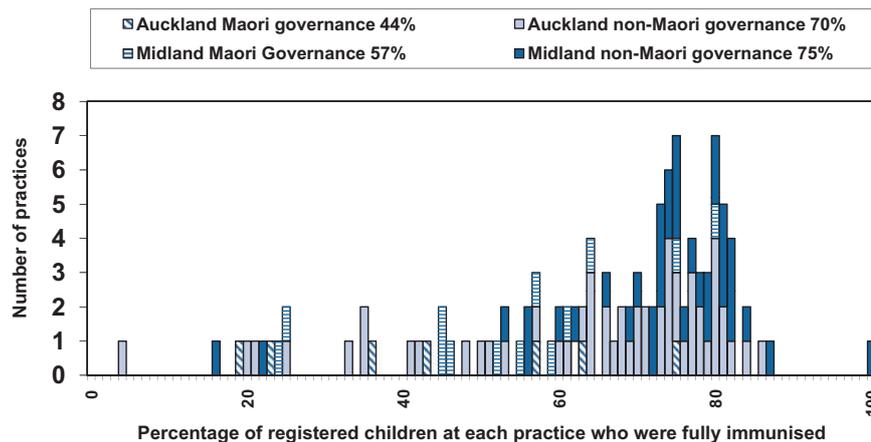


Fig. 2 Median percentage of children registered at each practice who were fully immunised.

Table 1 Practice immunisation coverage by socio-economic deprivation, practice funding and whether an urban or rural practice

Variable (number of practices)	Median practice immunisation coverage (25th–75th centile)				P-value†
	Auckland		Midland		
Region					
Governance	Māori n = 7	Non-Māori n = 61	Māori n = 14	Non-Māori n = 36	
Percentage of registered patients in most socio-economically deprived quintile‡ (118)					<0.001§
Less than 30% (86)	51 (44–58)	71 (63–78)	76 (46–80)	75 (71–80)	
30% or more (32)	36 (24–64)	63 (33–66)	56 (46–62)	77 (57–81)	
Access funding¶ (118)					0.28‡‡
No (72)	–††	71 (63–78)	80 (80–80)	75 (71–80)	
Yes (46)	44 (24–64)	65 (36–70)	56 (46–62)	75 (70–81)	
Urban or rural practice§§ (110)					0.20‡‡
Urban (90)	41 (22–66)	70 (63–77)	55 (46–62)	75 (73–81)	
Rural (20)	36 (36–36)	54 (52–65)	60 (56–65)	76 (57–80)	

†Analysis adjusted for region and governance. ‡Percentage in most socio-economically deprived quintiles included in the model as a continuous variable. §Based on the NZDep2001 Index of Deprivation, a small area-based measure that combines nine variables from the 2001 census, which reflects aspects of material and social deprivation.²⁴ ¶A practice is eligible for access funding if 50% of enrolled patients are from high-deprivation communities or are of Māori or Pacific ethnicities. ††No practices in this category. ‡‡Adjusted for region, practice governance and socio-economic deprivation of the registered population. §§As defined by a national rural ranking scale.²⁵

quintile increased ($P < 0.001$). After adjustment for region, practice governance and socio-economic deprivation, there were no associations between the proportion of the registered practice population that was Māori ($P = 0.48$) or Pacific ($P = 0.15$) and the practice coverage (data not shown).

Characteristics of the children and the practice (Table 2)

Coverage decreased as median age of the registered children at the practice increased ($P < 0.001$) and as the median registration age increased ($P = 0.001$). The median percentage of registered children receiving each of the scheduled immunisations decreased with increasing age, with this association being most apparent for immunisations scheduled in the second year of life

(6 weeks 93%, 3 months 91%, 5 months 87%, 15 months 71%).

Practice coverage was higher at practices where the practice management system MedTech (MedTech Limited, Auckland, NZ) was used rather than one of the three alternative computer software programmes ($P < 0.001$). Practice out-of-pocket patient fees charged for children <6 years old varied from \$0 to \$30 per appointment. After adjustment for social deprivation, region and governance, neither co-payments nor the proportion of patients that owed money was associated with coverage.

Nurse characteristics (Table 3)

Approximately half (48%) of the nurses worked full time. Ninety-five per cent of nurses reported they were the health

Table 2 Practice immunisation coverage by characteristics of the registered children and of the practice

Variable (number of practices)	Median practice immunisation coverage (25th–75th centile)				P-value†
	Auckland		Midland		
Governance	Māori n = 7	Non-Māori n = 61	Māori n = 14	Non-Māori n = 36	
<i>Characteristics of the registered children < 2 years old</i>					
Median age of children (118)					<0.001
Less than 13 months (48)	54 (44–64)	70 (66–75)	60 (58–69)	78 (73–82)	
13 months or older (70)	36 (24–58)	66 (52–78)	49 (46–62)	75 (62–79)	
Median age of children at registration (118)					<0.001
Less than 3 months (72)	–‡	73 (63–77)	58 (46–62)	75 (73–80)	
3 months or older (46)	44 (24–64)	67 (42–71)	56 (47–62)	75 (62–79)	
Number of registered children (118)					0.59
Less than 150 (71)	40 (28–54)	70 (63–77)	57 (46–62)	75 (71–80)	
150 or more (47)	58 (24–75)	67 (42–75)	61 (47–76)	74 (67–82)	
Percentage of children seen at practice who were registered (118)					0.31
Less than 75% (56)	36 (20–44)	68 (53–75)	62 (56–65)	74 (56–81)	
75% or more (62)	61 (41–70)	70 (63–78)	47 (46–52)	76 (73–80)	
<i>Characteristics of the practice</i>					
MedTech is the patient management system used (117)					P-value§ <0.001
Yes (89)	51 (36–64)	71 (65–77)	58 (47–65)	75 (73–81)	
No (28)	20 (20–20)	63 (45–76)	52 (36–60)	75 (56–79)	
Practice charges for appointments for registered children (117)					0.20
No (86)	44 (24–64)	67 (52–77)	56 (46–62)	74 (62–79)	
Yes (31)	–‡	75 (67–79)	80 (80–80)	80 (74–82)	
>15% of registered patients at the practice owed money (116)					0.27
Yes (43)	51 (24–64)	63 (52–73)	54 (46–62)	73 (65–77)	
No (73)	36 (36–36)	73 (65–78)	60 (52–63)	76 (70–82)	
Immunisation audited at least monthly (117)					0.25
Yes (32)	58 (37–75)	69 (52–73)	69 (62–76)	74 (70–80)	
No (85)	34 (22–54)	73 (65–78)	54 (46–61)	76 (71–82)	
Practice has specific immunisation clinics or appointments (117)					0.27
Yes (40)	44 (36–64)	70 (62–75)	52 (47–76)	81 (67–82)	
No (77)	41 (22–66)	70 (61–77)	58 (46–62)	75 (73–79)	
Practice has staff shortages (117)					0.06
Yes (76)	51 (36–64)	69 (52–75)	56 (46–62)	73 (67–80)	
No (41)	20 (20–20)	70 (64–79)	76 (46–80)	79 (75–81)	

†Adjusted for region, practice governance and socio-economic deprivation of the registered population. ‡No practices in this category. §Adjusted for region, practice governance and socio-economic deprivation of the registered population, age and registration age of children <2 years old.

professionals usually responsible for administering vaccines. Most (94%) had completed a vaccinator training course and virtually all (98%) were confident about their ability to deliver childhood immunisations.

Practice coverage was higher if the nurse had dedicated time for immunisation follow up ($P = 0.01$) and if the nurse perceived parental fear ($P = 0.02$) or apathy ($P = 0.01$) as a barrier to immunisation.

Doctor characteristics (Table 4)

Eighty per cent of the 112 doctors worked full-time, of whom 61% had more than 10 years experience.

Parental apathy was perceived as a barrier to immunisation by 70% of doctors, parental fear or ambivalence by more than half

and access difficulties by 19%. Doctor perception of access difficulties as a barrier to immunisation was associated with higher coverage ($P = 0.04$).

The majority (84%) of doctors were confident in their immunisation knowledge, and such confidence was associated with higher coverage ($P = 0.002$). Knowledge regarding contraindications to immunisations was variable and incomplete. Correct knowledge was associated with higher coverage.

Caregiver characteristics

A median of eight caregivers per practice (total = 957) participated in the survey. The majority (67%) made their decision regarding immunisation while pregnant. Only 62% of caregivers reported having received immunisation information

Table 3 Practice immunisation coverage by practice nurse characteristics

Variable (number of practices)	Median practice immunisation coverage (25th–75th centile)				P-value†
	Auckland		Midland		
Region					
Governance	Māori n = 7	Non-Māori n = 61	Māori n = 14	Non-Māori n = 36	
<i>Nurse workload and experience</i>					
Ratio of practice nurses to children (115)					0.31
1:75 to 1:290 (30)	24 (24–24)	67 (52–71)	49 (47–52)	75 (73–79)	
1:1 to 1:74 (85)	51 (36–64)	73 (64–77)	58 (46–63)	75 (71–82)	
Nurse has dedicated time for immunisation follow up (108)					0.01
Yes (67)	47 (36–58)	70 (62–77)	62 (56–65)	78 (67–81)	
No (41)	22 (20–24)	70 (45–74)	52 (46–59)	74 (70–77)	
5 years or more of experience (107)					0.15
Yes (81)	36 (20–58)	70 (63–77)	59 (46–65)	75 (73–80)	
No (26)	24 (24–24)	68 (45–74)	59 (58–62)	65 (55–78)	
<i>Nurse attitudes</i>					
Perceives parental apathy as barrier to immunisation (109)					0.02
Yes (56)	58 (58–58)	70 (63–75)	62 (43–63)	78 (73–82)	
No (53)	24 (20–36)	68 (52–77)	57 (49–67)	72 (62–75)	
Perceives parental fear as a barrier to immunisation (109)					0.01
Yes (66)	36 (20–58)	71 (57–79)	58 (46–62)	75 (71–81)	
No (43)	24 (24–24)	67 (62–74)	62 (56–76)	74 (55–78)	
Perceives parental ambivalence as a barrier to immunisation (109)					0.54
Yes (54)	58 (58–58)	71 (57–78)	57 (52–62)	75 (67–80)	
No (55)	24 (20–36)	69 (62–75)	61 (46–76)	75 (74–82)	
<i>Nurse contraindication knowledge</i>					
Knowing that a 'cold' is not a contradiction§ (107)					0.07
Yes (83)	24 (20–36)	70 (62–75)	58 (36–63)	75 (70–80)	
No (24)	58 (58–58)	70 (52–78)	62 (52–76)	75 (65–78)	
Knowing that a previous HHE is not a contradiction¶ (79)					0.09
Yes (41)	24 (24–24)	73 (64–77)	62 (62–62)	73 (57–80)	
No (38)	36 (20–58)	68 (52–75)	59 (52–75)	74 (70–78)	
Knowing that a rash after eating eggs is not a contradiction§ (93)					0.84
Yes (60)	–‡	71 (62–77)	71 (62–80)	75 (73–82)	
No (33)	36 (20–58)	67 (52–71)	56 (38–67)	75 (71–80)	

†Adjusted for region, practice governance and socio-economic deprivation of the registered population, age and registration age of children <2 years old.
‡No practices in this category. §With respect to MMR vaccine. ¶With respect to acellular pertussis vaccine. HHE, hypotonic hyposensitive episode; MMR, measles mumps rubella.

antenatally. Twenty-nine per cent of caregivers received information that discouraged them from immunising their child. Receipt of such information was associated with lower coverage (67% vs 73% $P = 0.03$).

Combined analysis (Table 5)

The multiple regression model of demographic, practice, nurse, doctor and caregiver associations with practice immunisation included 76 practices and explained 80% of the variance in coverage between these practices. Coverage varied with region ($P = 0.002$) and practice governance ($P < 0.001$). Coverage decreased as socio-economic deprivation of the registered practice population increased ($P < 0.001$), as the average age of the children increased ($P < 0.001$) and as the registration age of

the children increased ($P < 0.001$). Immunisation coverage was higher at practices that experienced no staff shortages (median practice coverage 76% vs 67%, $P = 0.004$), where the doctor was confident in his/her immunisation knowledge (72% vs 67%, $P = 0.005$) and where the nurse had dedicated time for immunisation follow up ($P = 0.05$). Coverage was lower at practices where caregivers had received discouraging information about immunisation antenatally (67% vs 73%, $P = 0.008$).

Discussion

Our survey demonstrated mediocrity and wide variability between practices in immunisation coverage. Socio-economic deprivation had a strong negative effect on coverage. Coverage was higher in practices that were able to formalise a relationship

Table 4 Practice immunisation coverage by doctor (family physician) characteristics

Variable (number of practices)	Median practice immunisation coverage (25th–75th centile)				P-value†
	Auckland		Midland		
Region					
Governance	Māori n = 7	Non-Māori n = 61	Māori n = 14	Non-Māori n = 36	
<i>Doctor perceptions of barriers to immunisation</i>					
Perceives parental access difficulties as a barrier (106)					0.04
Yes (19)	58 (58–58)	70 (63–75)	69 (44–78)	74 (22–75)	
No (87)	24 (20–36)	70 (61–77)	56 (46–59)	77 (70–82)	
Perceives parental apathy as a barrier (106)					0.25
Yes (70)	36 (29–58)	67 (52–75)	55 (36–63)	75 (71–81)	
No (36)	24 (24–24)	74 (68–80)	59 (56–62)	75 (61–79)	
Perceives parental fear as a barrier (106)					0.22
Yes (58)	36 (36–36)	71 (52–77)	54 (46–59)	76 (73–82)	
No (48)	24 (20–58)	70 (65–77)	62 (46–76)	72 (57–80)	
Perceives parental ambivalence as a barrier (106)					0.59
Yes (50)	47 (36–58)	73 (62–77)	54 (36–63)	77 (71–82)	
No (56)	22 (20–24)	69 (63–75)	59 (58–62)	74 (61–80)	
<i>Doctor immunisation practice and knowledge</i>					
Confident in knowledge about immunisation (106)					0.002
Yes (84)	30 (22–47)	70 (63–77)	62 (56–65)	76 (70–81)	
No (22)	–‡	68 (46–78)	39 (25–56)	73 (70–81)	
<i>Doctor contraindication knowledge</i>					
Knowing that being treated for leukemia is a reason to delay immunisations§¶ (73)					0.01
Yes (46)	–‡	72 (67–75)	62 (59–65)	75 (73–81)	
No (27)	58 (58–58)	63 (52–74)	39 (26–52)	71 (56–78)	
Knowing that fever is not a contradiction§ (106)					0.04
Yes (73)	30 (22–47)	71 (65–78)	58 (46–65)	78 (74–83)	
No (33)	–‡	64 (42–75)	56 (46–62)	73 (61–80)	
Knowing that a rash after eating eggs is not a contradiction¶ (81)					<0.001
Yes (47)	30 (24–36)	74 (69–79)	60 (26–65)	75 (73–80)	
No (34)	58 (58–58)	70 (63–75)	60 (56–69)	76 (57–81)	

†Adjusted for region, practice governance and socio-economic deprivation of the registered population, age and registration age of children <2 years old.
‡No practices in this category. §Rather than as not a contraindication or a reason never to immunise the child. ¶With respect to MMR vaccine. MMR, measles mumps rubella.

with children at a younger age. Practices wherein the staff were confident about immunisation and wherein immunisation was an organisational priority achieved higher coverage. Immunisation coverage suffered when practices experienced staff shortages.

Socio-economic deprivation, rather than ethnicity, was the dominant determinant of practice coverage. Much of the apparent association between ethnicity and immunisation coverage was explained by the confounding effect of social deprivation. Our analysis confirms that factors associated with socio-economic deprivation are powerful barriers to immunisation.¹¹ Such barriers can be overcome but require additional resources to provide education, to identify the children who need to be immunised, to use opportunistic and outreach immunisation, and to have ready access to an accurate and complete immunisation register.²⁶

Coverage varied by both region and practice governance. The regional differences were not explained by differences in socio-

economic deprivation nor by the more rural demographics of the Midland region.^{16,27} Although there is a national immunisation schedule, the resources devoted to immunisation delivery are likely to vary by District Health Board and hence region, both in amount and areas of focus for resourcing. Such variance in funding may account for these regional differences.

Coverage was lower in Māori governance practices. A nationally representative survey of Māori providers showed they serve a young patient population, which is disproportionately from more deprived areas.¹⁴ Māori governance practices have community representation as a feature of their governance structure and employ more community health workers. A larger proportion of patients are seen by nurses rather than by doctors at these practices. These aspects of structure provide a framework within which immunisation delivery by these practices can improve.¹⁴

That the formation of an early relationship with the primary care practice is a critical aspect of immunisation delivery is

Table 5 Combined analysis of practice, child, health professional and caregiver associations with practice immunisation coverage

Variable	Direction of effect on coverage	Multivariate P-value
<i>Demographics</i>		
Region		0.002
Auckland	Higher in Midland	
Midland		
Governance		<0.001
Māori governance	Higher in non-Māori governance practices	
Non-Māori governance		
Socio-economic deprivation	Decreased with increased socio-economic deprivation	<0.001
Age of registered children	Decreased with increasing age	<0.001
<i>Practice</i>		
Age of children at registration	Decreased with increasing age at registration	<0.001
Staff shortages	Higher in practices that did not have staff shortages	0.004
<i>Nurse</i>		
Nurse has dedicated time for immunisation follow up	Higher at practices where the nurse has dedicated time	0.05
<i>Doctor</i>		
Doctor confident in knowledge about immunisation	Higher at practices where the doctor is confident in his/her knowledge	0.005
<i>Caregiver</i>		
Received discouraging information about immunisation antenatally	Lower at practices where the caregivers received discouraging information	0.008

Other variables in the model for which associations with coverage were not significant: patient management system used ($P = 0.14$), nurse comfortable with own immunisation knowledge ($P = 0.98$) and nurse perception of parental fear ($P = 0.17$) or apathy ($P = 0.20$) as barrier to immunisation.

self-explanatory. Delay in the receipt of the first dose in the primary series is one of the strongest predictors of subsequent incomplete immunisation.^{28–30} NZ needs more effective facilitation of early registration of newborns with the primary care practice, in particular improving the process of transition from perinatal care providers.

Achieving this important early relationship in the NZ context is surprisingly complex. Since the 1990s, primary health care during pregnancy and post-partum has been delivered predominantly by midwives.³¹ Post-natally, the midwife refers the newborn infant to two different well care providers: the primary care practice for that child's immunisations and another provider for most other components of well child care.³² Earlier registration will require better communication and coordination between these various providers. NZ needs to consider the better integration of general practice with well child care and the reintroduction of general practitioners into antenatal care.³³

As caregiver decision-making regarding immunisation occurs predominantly before the child is born, this is the most appropriate time to provide education about immunisation. Parental immunisation knowledge improves when such antepartum education is provided.³⁴ Seizing this 'teachable moment' to support informed decision-making regarding immunisation would also remove the opportunity that the anti-immunisation lobby currently appears to have for their message to be heard first.^{35,36}

Health literacy across both the health professionals and the public is likely to have an effect on immunisation coverage, and further studies may be warranted to delineate this factor further.

This study had several limitations. The response rate was 61%. This project coincided with a national immunisation strategy to control a meningococcal epidemic and a large primary care practice accreditation process in the Midland region. Both affected practices' ability to engage with this project. Practices that struggled to cope with these competing issues may have been less likely to participate in this study. Despite this, we recruited a sample of urban and rural practices that served a wide socio-economic and ethnic spectrum, and had immunisation coverage that spanned a range from 4% to 100%.

We were limited to interviewing one doctor and one nurse from each practice. Their responses may not have been representative of all practice staff. Seeking to interview multiple doctors and nurses would have resulted in an unacceptably high respondent burden. The number of caregivers enrolled from each practice was small. With privacy considerations preventing us access to patient lists and hence reliance upon practice staff to make the initial contact, we had to accept a smaller sample than might have been desirable.

This study demonstrates that there are modifiable primary care determinants of immunisation coverage. These include early establishment of a relationship between the health-care provider and the child's caregivers, having a practice that is adequately resourced with stable staffing and confident health providers who place a priority on the delivery of quality immunisation services. These are the key determinants of a practice's ability to immunise the children for whom it is the identified health-care provider. Individual practices with such characteristics can obtain high immunisation coverage, even in areas of

high socio-economic deprivation and in an environment where there is overall mediocre coverage.

Acknowledgements

We wish to acknowledge the contributions made by the following people to this project: Mrs Jackie Copp, who developed the project relational database and managed the project; and Dr Naidu Madupuri and Mrs Mildred Lee, who managed the project dataset and completed the initial phases of data editing and analysis.

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