BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-025535
Article Type:	Research
Date Submitted by the Author:	22-Jul-2018
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Keywords:	healthcare disparities, data linkage, childhood intervention

How Universal are Universal Pre-School Health Checks? Evidence from New Zealand's B4 School Check

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Key words: healthcare disparities; data linkage; childhood intervention

Word count: 3435

Funding: This study was funded by A Better Start – National Science Challenge, New Zealand Ministry for Business, Innovation and Employment.

Ethical approval: This study was approved by the University of Otago Human Ethics Committee (ref D16/088.)

Disclaimer: Access to the data used in this study was provided by Statistics New Zealand under conditions designed to give effect to the security and confidentiality provisions of the Statistics Act 1975. The results presented in this study are the work of the authors, not Statistics NZ.

Abstract

Objectives: We aimed to estimate how many children were not attending a universal pre-school health screen and to identify characteristics associated with non-participation

Design: Analysis of population level linked administrative data

Participants: Children were counted in the population of resident 4-year-olds for a given year if 1) they were ever resident in New Zealand, and 2) they lived in NZ for at least 6 months during the reference year, and 3) they were alive at the end of the reference year, and either 4) Appeared in any hospital (including emergency) admissions, community pharmaceutical dispensing, or GP enrolment datasets during the reference year, or 5) had a registered birth in New Zealand. We analysed 252,273 records from children over 4 years, from July 1st 2011 to June 30th 2015.

Results: We found that participation rates varied markedly for each component of the B4 School Check (in 2014/15 91.8% for Vision and Hearing tests (VHT), 87.2% for nurse checks (including height, weight, oral health, SDQ, PEDS) and 62.1% for Teacher SDQ (SDQT)), but participation rates for all components increased over time. Māori and Pacific children were more likely to miss out on VHT (Māori OR=1.67(1.63,1.72) Pacific OR=1.73(1.67,1.78)), nurse checks (Māori OR=1.60(1.56,1.63) Pacific OR=1.49(1.45,1.53)) and SDQT (Māori OR=1.32(1.29,1.34) Pacific OR=2.70(2.63,2.76)) than non-Māori and non-pacific children. Children from lower socioeconomic households, born to young mothers, with worse health status, from rented homes, residing in larger households, with higher rates of residential mobility were less likely to participate in the B4 School Check than other children.

Conclusion: The patterns of non-participation suggest a reinforcing of existing disparities, whereby the children most in need are not getting the services they require. There needs to be an increased effort by public health organizations, community and whānau to ensure that all children are tested and screened.

Strengths and limitations of this study

- Whole population sample of all children completing B4 School check over 4 years (N=252,273)
- Using linked data from different sectors provided information about a wide range of characteristics
- Only bivariate analyses were possible; sample loss due to missing data meant that multivariate analysis was not feasible

Introduction

Globally, a common practice in childhood development is to screen children to determine if there are any key developmental problems that need to be assessed. These screens typically check for problems relating to general health, including hearing, vision, height, weight and oral health. They also often screen for emotional, behavioural, or intellectual issues that might be evident (1). Hall and Stewart-Brown categorize four types of screening programmes: i) biochemical; ii) screening involving objective measures (such as height and weight, vision and hearing; iii) screening involving physical examination; and iv) screening involving understanding of child development (2). Although there is some disagreement on what children should be screened for, how and when, there is a general consensus that screening in early childhood accompanied with targeted interventions is worthwhile (3).

In New Zealand, the screen is called the Before School Check (B4SC) and it is administered to four year olds. The B4SC was implemented in New Zealand starting in September 2008, although it was not universal until 2010. There are eight key developmental areas that are assessed: vision, hearing, oral health, general health, growth measurement, strengths and difficulties (SDQ) as reported by parents and teachers and a parental evaluation of development status (PEDS). If concerns are identified in any area, children are referred for further testing or intervention. The B4SC is administered by the Ministry of Health, which has set a target 90% participation rate across the country, with parents and guardians being notified of the B4SC via enrolment with a primary health care provider (PHO). The Ministry's data suggests they have been meeting their target since 2013, but compliance falls short of 100% (4). Furthermore, not all four year olds (96%) are registered with a PHO (5), and including these unregistered children in the denominator may further reduce compliance rates.

This raises three concerns: First, that a non-trivial number of children are missing their checks. Second, that some children may not be registered with a PHO and as such, their parents are not notified that their child should attend a B4SC. And third, that these children may be more likely to be in higher risk categories and could benefit from the referrals to interventions that accompany this screen. It is this final concern that is the focus of this study.

Evidence Preschool / School Entry Screening Participation

Across different universal health checks available to the adult populations of different countries certain patterns persist: those in poorer socioeconomic circumstances, with lower qualifications, at greater risk of health problems are less likely to attend such checks (6).

The available evidence for universal health checks in childhood suggests a similar pattern. Wood et al considered the coverage of universal child health reviews in Scotland (7). They considered two cohorts of children, the first, born in 1998/99 were eligible for 5 health checks (10 days/6-8 weeks/8-9 months/22-24 months and 39-42 months) and a second cohort, born in 2007/08, were only eligible for the first two checks. They found that coverage rates of the 10-day check were very high in both cohorts (99%), but this declined as the children aged. For the 6-8 week review, coverage was between 94-95%, and for the 39-42 month review the coverage rates fell to 86%. There were clear deprivation gradients, with children living in the least deprived areas much more likely to have a health check than those in the most deprived areas, and these gradients increased substantially with increasing age and decreasing coverage. They conducted an audit on a subset of the areas included in the review (Glasgow and Fife). Consistent with the inverse care law (8) they found that children who missed the 6-8 week review were more likely to require additional health services and support in the future than those who attended the review.

Similarly, findings from the National Child Measurement Programme (9), a population level screen of BMI among children at ages 4-5 and 10-11 in the UK, shows that despite very high coverage rates (≥93% from 2009 onwards), children not captured by the screen are more likely to live in deprived areas and are more likely to have a higher BMI.

These universal checks are often the only instrument to identify children in need of additional services, who may otherwise be missed by the health system. The early identification of health and developmental issues increases the efficacy and cost effectiveness of treatment and lessens the risk of any potential comorbidities. Therefore, these systematic differences in attendance highlight a crucial issue: Those children most in need are missing out on vital services.

In New Zealand we are in a unique position to examine the characteristics of those not completing the B4SC. Many routinely collected government databases (including B4SC) are held in the Statistics New Zealand Integrated Data Infrastructure (IDI) and each individual is assigned a unique identifier which allows their records to be linked across data files. In this analysis we build a population cohort using birth records and immigration/emigration files to determine which four year-olds were in the country and eligible for the B4SC between July 1st 2011 to June 30th 2015, and then we examine the characteristics of those who do not get the B4SC.

The aim of this paper is to identify characteristics associated with non-participation in the B4SC by linking to deprivation, birth, census, health, disability and immunisation records, all of which are housed in the IDI and are linkable through a person specific unique identifier created by Statistics New Zealand.

Methods

Data

All data were sourced from the Integrated Data Structure (8), a secure database containing anonymised microdata about individuals.

B4 School Check

The B4 School Check (B4SC) is a universal programme offered to all families in New Zealand with four-year-old children (9). The percentage attending the B4SC was estimated as 79% in 2011/2012, 80% in 2012/2013, 91% in 2013/2014, 92% in 2014/15, and 92% in 2015-2016 (4). High coverage of vulnerable groups (Māori children and children from areas of high socioeconomic deprivation) is encouraged by linking a portion of DHB funding for B4SC to coverage targets these groups. In the 2015/16 year the coverage for Māori children was 88% and for Pacific children it was 89% (10). For children from high deprivation areas the coverage was 93% (4). This paper uses data from B4 school checks completed between the fiscal years 2011/12 and 2014/15.

Population

To identify the population of children eligible for a B4SC, annual populations of four-year-old children were constructed using methods developed previously for constructing populations from the Integrated Data Infrastructure (IDI) (10,11). Children were included in the population for a given year if they lived in NZ for at least 6 months during the reference year, were alive at the end of the reference year, were included in the IDI spine (which aims to cover an “ever-resident” population including all those who either were born in New Zealand, migrated to New Zealand, or paid tax in New Zealand (11)), and:

- Appeared in any hospital (including emergency) admissions, community pharmaceutical dispensing, or GP enrolment datasets during the reference year; OR

- Had a NZ birth record.

The effects of changing the criteria for inclusion in the population are shown in the sensitivity analysis in Appendix 2

Patient and public involvement

Patients and public were not involved in the design or conduct of this study.

Measures

B4SC completion

For the purposes of this study, B4SC components that are usually administered together were grouped together, creating three components: Vision and Hearing Test (VHT) checks (vision and hearing); nurse checks (growth, dental, immunisation, Parents Evaluation of Developmental Status (PEDS), and Strengths and Difficulties Questionnaire (SDQ) Parent); and SDQ Teacher. If a child had completed all checks within a component they were considered to have completed that component. B4SC coverage was calculated as the number of children completing a B4SC component divided by the total number of children in the population. Completion rates for the individual component checks can be found in Appendix 1.

Ethnicity

Ethnicity measures were taken from the source ranked ethnicity table in IDI. The table collates ethnicities that are reported to different administrative collections in IDI and ranks these sources to provide a single ethnic profile for each individual. Ranking is based on how closely the ethnicities reported for an individual in the administrative source match those reported in the

census (census records have highest priority and 84.3% of the study population had ethnicity sourced from census, followed by birth records (13.9%), followed by health (1.7%))(12). From this we constructed four dichotomous ethnicity variables representing membership of each of the following major ethnic groups: Māori; Pacific; Asian; European. The MELAA (Middle Eastern, Latin American and African) and Other ethnic groups were not used in this study as the number of children in these groups was too small. Individuals could belong to more than one ethnic group. Identifying as more than one ethnicity is common in New Zealand (13) and 23.9% of the current sample belonged to multiple ethnic groups. Ethnicity information was available for all of children in the sample.

Socioeconomic deprivation

NZ Deprivation Score (NZDep) was calculated using the standard 2013 NZDep concordance(14) and the child's meshblock of usual residence at the time of the 4th birthday, or the first meshblock recorded within 12 months after the date of the 4th birthday if no meshblock was recorded prior to that. Each meshblock was assigned a score from 1 (least deprived) to 10 (most deprived). Deprivation information was available for 99.7% of children in the sample.

Urbanicity

The child's meshblock of usual residence was also used to define urbanicity. The standard classification of urban/rural areas in New Zealand (15)is a five-point scale: 1) Main urban (centred on a city or major urban area, population of at least 30 000), 2) secondary urban (centred on larger regional centres, population 10 000-29 999), 3) minor urban (centred around smaller towns, population 1 000–9 999), 4) rural centre (population 300-999) and 5) other rural. These were collapsed into two groups: urban (main urban, secondary urban, and minor urban area) and rural

(rural centre and other rural). Urbanicity information was available for 99.7% of children in the sample.

Residence changes

The total number of different addresses lived at from birth to fourth birthday (minus one to give the number of changes) was calculated from the address notification table in IDI which collates address updates reported to data providers. Number of residence changes was available for all children in the sample.

Hospitalisations

The following variables were obtained from hospital records: total number of hospital admissions (excluding the child's birth and any emergency department visits that did not result in hospital admission) from birth to fourth birthday; the total number of days spent in hospital for those visits; total number of emergency department visits from birth to fourth birthday. Hospitalisation information was available for all children in the sample.

GP enrolment

The extent to which a child had continuous enrolment with a general practitioner was estimated by counting the number of quarters in which a child was enrolled with a Primary Health Organisation (umbrella organisations for general practitioners) from birth to fourth birthday. GP enrolment information was available for all children in the sample.

Disability

Children who received a referral to Disability Support Services before their fourth birthday were classified as having a disability. This information was available for all children in the sample.

Information from birth record

Birth records were available for 94.1% of the total sample. The following variables were obtained from the child's birth record: the child's birth weight, in grams; gestational age, categorised into <37 weeks, 37-42 weeks, and >42 weeks; whether or not a father was recorded on the child's birth certificate; age of the child's mother at the time of the child's birth, grouped into under 20; 20-24; 25-29; 30-34; 35 and over.

Variables from census records

Additional variables were obtained by linking to census records. Household variables were obtained by linking to the household form connected to the child's census record, 82.9% of children had census household information available. Mother and father variables were obtained by first linking to the child's birth record to identify mother and father, and then linking to census records for the mother and father. 79.8% of children had mother census information available; 68.5% had father census information available. All census variables are recorded as at 5 March 2013. The variables from Census were: size of household (including child), grouped into: 2 to 4 people; 5 to 7 people; 8 or more people; whether the dwelling was rented or owned (including those held in family trusts); whether or not any member of the child's household received benefit income in the year to 5 March 2013; whether or not the child's mother spoke enough English to have a conversation about everyday things; the highest qualification of the child's mother and father at the time of the 2013 census, classified into: no formal qualifications; high school qualifications; tertiary qualification below Bachelor degree; Bachelor degree or higher; the current

smoking status of the child's mother at the time of the census, classified into: current regular smoker; ex-smoker; never smoked.

Analysis

All analyses were conducted using SAS Enterprise Guide version 9 within the secure data lab environment. First, we constructed the population, and calculated rates of those who completed components (VHT, nurse checks, SDQT) of the B4SC. Second, we compared the characteristics of those who did not complete a component compared to those who did, and calculated unadjusted odds ratios and 95% confidence intervals.

Results

Table 1 shows the percentage of children who completed the VHT, nurse and SDQT components of the B4SC, by year. In all years, completion was highest for the VHT component and lowest for the SDQ Teacher component. Approximately 52% to 62% of children completed the SDQ Teacher component, compared to 78% to 87% for the nurse components and 86% to 91% for the VHT components. Coverage was lowest in 2011/12 and highest in 2014/15.

INSERT TABLE 1 HERE

Table 2 shows the associations between completion of each B4SC component for 2011/12 to 2014/15 (all years combined), and a range of socioeconomic, family, housing, and health status characteristics. The table shows the percentage of children completing each component, the odds ratio and 95% confidence intervals.

INSERT TABLE 2 HERE

Discussion

Our results demonstrate that Māori and Pacific children, those in poorer socioeconomic circumstances, with poorer health are less likely to complete the B4SC. Children in families with higher levels of deprivation, without a father named on the birth certificate, with mothers and fathers with lower levels of education, living in households with 5 or more people, having multiple changes in residence in the early years of life and living in rental accommodation have a lower likelihood of B4SC completion. Our results paint a consistent pattern, demonstrating that across a wide range of measures of vulnerability, those children who would potentially most benefit from a B4SC screen and the referrals to interventions are less likely to participate.

A strength of this study is the large, linked dataset that was used (the Integrated Data Infrastructure, IDI). The IDI is a whole population data source and therefore it allows us to include children who are often excluded from other analyses, such as those not in regular contact with health services. Furthermore, the large number of data sources included in the IDI allows us to examine a wider range of characteristics than would be available in any single source.
While this study is novel, and provides vital information for service providers, all of the analyses presented in this paper are bivariate. To run adjusted models we would have to restrict our sample to children born in NZ, with a mother and father who completed 2013 census. These restrictions would reduce the sample to less than 70% of the total sample and exclude all migrants, making the results difficult to generalise to the whole population.

Our findings are similar to those of Wood et al (7), and provide further support for the inverse care law – that those with the greatest need are the least likely to seek services (16). There is currently very little research in this area for child health screens, but the application of the inverse care law

is a consistent finding among free health checks for the adult population (17-20). However, the reasons why people most in need do not attend are not well understood, and there is a need for qualitative research investigating why parents are not taking children to free health checks (7).

Several potential explanations for non-attendance at adult health checks have been put forward that may be applicable to child health checks including; lack of awareness, time constraints and access issues (18), and misunderstanding the purpose/scepticism. Lack of awareness may be an issue for some parents, as not all eligible children are enrolled on the PHO system (96%), and some of those that are enrolled will have incorrect address information. These parents will not receive the invitation to the B4SC. Access could also be an issue with many of the B4 School checks being carried out by Plunket or other health services which are only open during normal office hours, and not at weekends (21). Therefore, households where both parents work, or single-parent working households will not easily be able to attend. Furthermore, for less densely populated regions in New Zealand there are fewer centres offering B4 School checks, compared to more densely populated regions such as Auckland or Wellington (21), meaning it is less convenient to attend. Scepticism about the value of attending and the purpose of the screens is likely to differ by ethnic group, as research persistently demonstrates that Māori receive a poorer quality and slower service, and are less likely to receive appropriate levels of care (22-24). There are similar findings for Pacific peoples also (25-27). Therefore these groups may be less trusting of the New Zealand health system (28),

Socioeconomic and ethnic Inequalities in health-seeking and health outcomes within New Zealand are well documented for both the adult and child population (29, 30). A long standing objective of the New Zealand government is to reduce health and socio-economic disparities, particularly for Māori and Pacific families. Patterns of participation at the B4SC could be reinforcing existing ethnic

and socioeconomic disparities. It is accepted that one of the most effective means of reducing inequities is through early intervention (31, 32). This appears to be the most likely and cost-effective path towards converging outcomes and it appears that many children who would benefit from these early interventions are not getting the opportunity to do so.

Although 100% attendance in the B4SC is unlikely, we believe that a greater effort is required to reach the most vulnerable families to ensure that more children who would benefit from the B4SC will get access to the interventions that arise from it. This will require greater outreach and public awareness, but also examining ways of providing access to the B4SC. An area where there has been some success in getting increased services to hard-to-reach populations has been through mobile programs and services (33, 34). In addition, direct contact with those not participating should be considered with a greater push to ensure that those with characteristics of vulnerability are encouraged to attend. Further research is necessary on barriers to attendance identified and remedial action taken.

We have not followed children to determine whether missing a B4SC does in fact have an impact on later life outcomes, and this clearly needs to be assessed. We plan to address this question in future work, although the limited time series for the B4SC means that we will only be able to examine outcomes up to age 15.

Conclusion

Using a rich and diverse range of measures, we find that those children most likely to be disadvantaged, are least likely to participate in the B4SC and as such get referrals for programs and interventions that may increase their readiness to enter school. We believe the patterns we observe in B4SC participation suggest a reinforcing of existing inequalities and require increased

effort to ensure that all children are tested and screened, and that those with the greatest need get access to health services, programmes and interventions.

Contributorship statement

RA, BM, BT and SG conceived the study. SG extracted data and did the main data analysis. NS provided statistical advice. All authors wrote and reviewed the manuscript, gave critical feedback and approved the final version for publication

Competing interests

None

Data sharing statement

Due to privacy regulations around the Integrated Data Infrastructure, data from this study are not available for sharing

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Table 1. Percentage of children completing B4SC components, by year

Fiscal year	N	% VHT complete	% nurse checks complete	% SDQ Teacher complete
2011/12	63,714	86.2	78.5	52.9
2012/13	62,664	88.5	81.4	57.3
2013/14	63,372	90.5	85.6	60.0
2014/15	62,529	91.8	87.2	62.1

Table 2. Percentage of children completing B4SC, and odds ratios for completing, by ethnic, socioeconomic, family, housing and health characteristics

		% complete			OR (95% CI)		
	N	VHT	Nurse checks	SDQ Teacher	VHT	Nurse checks	SDQ Teacher
Sex							
Male	129,831	89.0	82.9	57.6	0.98 (1.01,0.96)	0.98 (1.00,0.96)	1.00 (1.01,0.98)
Female	122,439	89.2	83.1	57.7	-	-	-
Ethnicity							
Māori	71,196	85.3	77.9	52.8	0.60 (0.61,0.58)	0.63 (0.64,0.61)	0.76 (0.78,0.75)
Pacific	37,857	84.0	77.8	37.0	0.58 (0.60,0.56)	0.67 (0.69,0.65)	0.37 (0.38,0.36)
Asian	30,825	91.2	86.8	52.3	1.30 (1.35,1.25)	1.39 (1.45,1.35)	0.78 (0.80,0.76)
European	173,235	90.8	84.6	63.4	1.67 (1.72,1.64)	1.41 (1.45,1.39)	2.13 (2.17,2.08)
Number of siblings at time of birth							
0	123,123	89.5	84.1	58.3	-	-	-
1	70,626	91.0	84.8	60.3	1.18 (1.22,1.15)	1.05 (1.09,1.03)	1.09 (1.11,1.06)
2+	43,527	86.0	78.2	52.3	0.71 (0.74,0.69)	0.68 (0.70,0.66)	0.78 (0.80,0.77)
Socioeconomic deprivation							

		% complete			OR (95% CI)		
	N	VHT	Nurse checks	SDQ Teacher	VHT	Nurse checks	SDQ Teacher
NZDep quintile							
1 (least deprived)	50,520	92.2	86.2	63.7	-	-	-
2	46,323	91.0	84.8	60.8	0.85 (0.89,0.81)	0.89 (0.93,0.86)	0.88 (0.91,0.86)
3	45,672	90.1	83.6	60.9	0.77 (0.80,0.74)	0.82 (0.85,0.79)	0.88 (0.91,0.86)
4	47,043	88.7	82.7	58.3	0.66 (0.69,0.64)	0.77 (0.79,0.74)	0.79 (0.81,0.78)
5 (most deprived)	61,854	85.4	79.3	47.7	0.50 (0.52,0.48)	0.62 (0.64,0.60)	0.52 (0.53,0.51)
Mother's highest qualification							
No formal qualifications	27,672	86.8	81.1	55.0	0.48 (0.51,0.46)	0.61 (0.63,0.58)	0.68 (0.70,0.66)
Secondary school	67,047	90.8	85.3	59.9	0.72 (0.75,0.69)	0.82 (0.85,0.79)	0.83 (0.85,0.81)
Tertiary qualification below Bachelor degree	41,901	91.7	85.6	60.7	0.81 (0.85,0.78)	0.84 (0.87,0.81)	0.86 (0.88,0.84)
Bachelor degree or higher	57,570	93.2	87.6	64.2	-	-	-
Father highest qualification							
No formal qualification	26,712	89.0	83.3	58.2	0.65 (0.68,0.61)	0.73 (0.76,0.70)	0.82 (0.85,0.79)
Secondary school	51,177	91.6	86.2	60.5	0.86 (0.91,0.82)	0.91 (0.94,0.88)	0.90 (0.93,0.88)

		% complete			OR (95% CI)		
	N	VHT	Nurse checks	SDQ Teacher	VHT	Nurse checks	SDQ Teacher
Tertiary qualification below Bachelor degree	47,391	92.6	87.0	64.5	0.99 (1.04,0.94)	0.98 (1.02,0.94)	1.06 (1.10,1.04)
Bachelor degree or higher	39,447	92.6	87.2	63.0	-	-	-
Member of household receives benefit income							
No	158,679	92.8	87.2	63.1	-	-	-
Yes	51,720	87.9	81.4	52.9	0.56 (0.58,0.55)	0.64 (0.66,0.63)	0.66 (0.67,0.65)
Family circumstances							
Age of mother at child's birth							
<20	14,310	83.2	76.8	49.6	0.48 (0.51,0.46)	0.56 (0.59,0.54)	0.64 (0.66,0.62)
20-24	41,889	86.7	80.3	53.8	0.63 (0.66,0.61)	0.69 (0.72,0.67)	0.75 (0.77,0.74)
25-29	55,800	89.5	83.7	57.8	0.83 (0.86,0.79)	0.88 (0.90,0.85)	0.88 (0.91,0.87)
30-34	66,297	91.2	85.4	60.7	-	-	-
35+	58,977	90.3	83.9	59.6	0.90 (0.93,0.87)	0.89 (0.92,0.86)	0.95 (0.97,0.93)
Father on birth certificate							
No	12,612	83.0	75.9	45.7	0.56 (0.59,0.53)	0.61 (0.64,0.59)	0.60 (0.62,0.57)

		% complete			OR (95% CI)		
	N	VHT	Nurse checks	SDQ Teacher	VHT	Nurse checks	SDQ Teacher
Yes	224,661	89.7	83.6	58.5	-	-	-
Mother speaks English							
No	3,483	89.1	85.4	46.4	0.81 (0.90,0.72)	1.00 (1.10,0.92)	0.56 (0.60,0.53)
Yes	196,248	91.0	85.3	60.6	-	-	-
Housing							
Urban	215,775	89.4	83.2	56.3	-	-	-
Rural	35,838	88.6	82.5	66.5	0.93 (0.96,0.89)	0.95 (0.98,0.93)	1.54 (1.59,1.52)
Household size							
2-4 people	120,849	92.9	87.7	64.4	-	-	-
5-7 people	77,808	90.6	84.0	57.8	0.74 (0.76,0.71)	0.74 (0.76,0.72)	0.76 (0.77,0.75)
8+ people	11,739	84.5	78.3	39.3	0.42 (0.44,0.40)	0.51 (0.53,0.49)	0.36 (0.37,0.34)
Own home	112,458	93.7	88.4	64.5	-	-	-
Rented home	93,840	89.2	82.9	56.4	0.56 (0.58,0.54)	0.64 (0.65,0.63)	0.71 (0.72,0.70)

		% complete			OR (95% CI)		
	N	VHT	Nurse checks	SDQ Teacher	VHT	Nurse checks	SDQ Teacher
Number of residence changes age 0-4							
None	52,602	89.7	85.1	61.1	-	-	-
1	55,359	92.7	87.3	61.1	1.47 (1.52,1.41)	1.20 (1.25,1.16)	1.00 (1.02,0.98)
2	42,087	91.4	85.4	58.7	1.22 (1.28,1.18)	1.03 (1.06,0.99)	0.90 (0.93,0.88)
3	28,320	89.3	82.6	56.4	0.96 (1.01,0.92)	0.83 (0.87,0.80)	0.83 (0.85,0.80)
4	18,675	87.9	80.0	54.8	0.83 (0.88,0.79)	0.70 (0.73,0.67)	0.78 (0.80,0.75)
5+	30,282	84.5	76.6	54.2	0.63 (0.65,0.60)	0.57 (0.60,0.55)	0.76 (0.78,0.74)
Health status							
Mother smoking status							
Regular smoker	38,460	86.8	80.7	55.2	0.56 (0.57,0.53)	0.63 (0.65,0.61)	0.78 (0.79,0.76)
Ex smoker	45,420	91.7	85.7	63.1	0.94 (0.98,0.90)	0.90 (0.93,0.88)	1.08 (1.10,1.05)
Never smoked	111,219	92.2	86.9	61.3	-	-	-
Birthweight							
<2500g	14,049	83.6	79.1	54.7	0.57 (0.60,0.55)	0.73 (0.76,0.70)	0.87 (0.90,0.84)
2500-4000g	187,239	89.9	83.8	58.1	-	-	-

		% complete			OR (95% CI)		
	N	VHT	Nurse checks	SDQ Teacher	VHT	Nurse checks	SDQ Teacher
>4000g	34,746	90.0	83.3	59.0	1.01 (1.05,0.97)	0.96 (0.99,0.93)	1.04 (1.06,1.01)
Gestation							
<37 weeks	17,925	84.3	79.5	55.2	0.60 (0.63,0.57)	0.76 (0.79,0.73)	0.88 (0.91,0.85)
37-42 weeks	217,128	89.9	83.7	58.3	-	-	-
>42 weeks	1,443	90.0	83.2	48.2	1.00 (1.19,0.85)	0.97 (1.11,0.84)	0.67 (0.75,0.61)
Child referred for disability support assessment							
No	247,878	89.4	83.3	57.9	-	-	-
Yes	4,401	74.3	65.4	43.6	0.34 (0.37,0.32)	0.38 (0.40,0.36)	0.56 (0.60,0.53)
Number of quarters enrolled with GP age 0-4							
0-3	16215	67.0	58.0	38.8	0.16 (0.17,0.16)	0.20 (0.21,0.19)	0.42 (0.44,0.41)
4-7	42645	86.8	78.9	55.5	0.53 (0.55,0.51)	0.54 (0.55,0.52)	0.83 (0.85,0.81)
8-11	95298	90.4	84.5	59.4	0.76 (0.79,0.74)	0.78 (0.80,0.76)	0.98 (1.00,1.00)
12+	98118	92.5	87.4	59.9	-	-	-
Number of hospital admissions age 0-4							

		% complete			OR (95% CI)		
	N	VHT	Nurse checks	SDQ Teacher	VHT	Nurse checks	SDQ Teacher
None	93,474	88.9	82.6	57.1	-	-	-
1 to 2	102,696	91.3	85.3	60.2	1.32 (1.35,1.28)	1.22 (1.25,1.19)	1.14 (1.15,1.11)
3 to 5	21,390	89.3	83.9	59.1	1.04 (1.09,0.99)	1.09 (1.14,1.05)	1.09 (1.11,1.05)
6+	9,762	84.8	78.9	55.3	0.69 (0.74,0.65)	0.79 (0.83,0.75)	0.93 (0.97,0.89)
Total days in hospital age 0-4							
None	123,231	89.3	83.2	57.8	-	-	-
1 to 9	95,478	91.1	85.1	60.2	1.23 (1.27,1.19)	1.15 (1.18,1.12)	1.10 (1.12,1.09)
10 to 19	4,953	87.3	81.6	53.8	0.83 (0.90,0.76)	0.90 (0.96,0.83)	0.85 (0.90,0.80)
20+	3,660	80.9	74.9	49.4	0.51 (0.55,0.47)	0.61 (0.65,0.56)	0.71 (0.76,0.67)
Total number of ED visits age 0-4							
None	193,905	89.9	84.0	60.1	-	-	-
1 to 2	31,173	89.7	82.7	50.6	0.97 (1.01,0.93)	0.91 (0.94,0.88)	0.68 (0.69,0.66)
3+	2,244	88.2	79.7	46.0	0.84 (0.96,0.74)	0.75 (0.83,0.68)	0.56 (0.61,0.52)

Note: As individuals can identify as multiple ethnicities, counts for ethnic groups will sum to greater than the count for the total population.

VHT = vision and hearing checks; Nurse = dental, growth, immunisations, PEDS, SDQP check

Appendix 1

Percentage of children completing each component of B4SC, by year

	% of children completing check			
B4 School check	2011/12	2012/13	2013/14	2014/15
Vision	86.8	88.7	90.7	91.8
Hearing	86.8	88.6	90.6	91.8
Dental	79.4	82.1	86.7	88.4
Growth	79.4	82.1	86.7	88.4
Immunisation	79.1	81.9	86.3	87.9
PEDS	79.4	82.1	86.6	88.4
SDQP	79.3	81.9	86.5	88.2
SDQT	52.9	56.5	59.8	61.4

Appendix 2

Sensitivity analysis

The table below shows the effects of:

1. Changing the criteria for inclusion in the population (column 1). In the main analyses, children were included in the population if they were in the IDI spine AND had health or birth records. Column 1 of the table below shows the results when the population was defined as children who were in the IDI spine OR had birth or health records.

2. Changing the overseas time cut-off for exclusion from the residential mobility and hospitalisation analyses (column 2, differences only apply to hospitalisation and meshblock change variables). In the main analyses, children were excluded if they had spent more than a year overseas. Column 2 of the table below shows the results if all children were included regardless of the amount of time spent overseas.

	Different population				Different overseas cut-off			
		OR (95% CI)				OR (95% CI)		
	N	VHT incomplete	Nurse checks incomplete	SDQ Teacher incomplete	N	VHT incomplete	Nurse checks incomplete	SDQ Teacher incomplete
Sex								
Male	136896	0.98 (1.01,0.96)	0.98 (1.00,0.96)	0.99 (1.01,0.98)	129834	0.98 (1.01,0.96)	0.98 (1.00,0.96)	1.00 (1.01,0.98)
Female	128967	-	-	-	122439	-	-	-
Ethnicity								
Māori	73092	0.76 (0.79,0.75)	0.74 (0.75,0.72)	0.81 (0.82,0.79)	71196	0.60 (0.61,0.58)	0.63 (0.64,0.61)	0.76 (0.78,0.75)
Pacific	39903	0.60 (0.62,0.59)	0.68 (0.69,0.66)	0.38 (0.39,0.37)	37857	0.58 (0.60,0.56)	0.67 (0.69,0.65)	0.37 (0.38,0.36)
Asian	33039	1.09 (1.12,1.04)	1.20 (1.23,1.16)	0.76 (0.78,0.75)	30825	1.30 (1.35,1.25)	1.39 (1.45,1.35)	0.78 (0.80,0.76)
European	180345	1.72 (1.75,1.69)	1.49 (1.52,1.47)	2.13 (2.17,2.13)	173232	1.67 (1.72,1.64)	1.41 (1.45,1.39)	2.13 (2.17,2.08)
	136896	0.98 (1.01,0.96)	0.98 (1.00,0.96)	0.99 (1.01,0.98)	129834	0.98 (1.01,0.96)	0.98 (1.00,0.96)	1.00 (1.01,0.98)
Number of siblings at time of birth								
0	123123	-	-	-	123126	-	-	-
1	70626	1.18 (1.22,1.15)	1.05 (1.09,1.03)	1.09 (1.11,1.06)	70629	1.18 (1.22,1.15)	1.05 (1.09,1.03)	1.09 (1.11,1.06)
2+	43527	0.71 (0.74,0.69)	0.68 (0.70,0.66)	0.78 (0.80,0.77)	43527	0.71 (0.74,0.69)	0.68 (0.70,0.66)	0.78 (0.80,0.77)
Socioeconomic deprivation								
NZDep quintile								
1 (least deprived)	52995	-	-	-	50517			
2	48081	0.89 (0.93,0.86)	0.92 (0.95,0.88)	0.89 (0.92,0.87)	46326	0.85 (0.89,0.81)	0.89 (0.93,0.86)	0.88 (0.91,0.86)

3	47283	0.82 (0.85,0.79)	0.85 (0.88,0.82)	0.89 (0.92,0.88)	45672	0.77 (0.80,0.74)	0.82 (0.85,0.79)	0.88 (0.91,0.86)
4	48720	0.72 (0.75,0.69)	0.79 (0.82,0.77)	0.81 (0.83,0.79)	47043	0.66 (0.69,0.64)	0.77 (0.79,0.74)	0.79 (0.81,0.78)
5 (most deprived)	64308	0.54 (0.56,0.53)	0.64 (0.66,0.62)	0.53 (0.54,0.52)	61854	0.50 (0.52,0.48)	0.62 (0.64,0.60)	0.52 (0.53,0.51)
Mother highest qualification								
No formal qualifications	27672	0.48 (0.51,0.46)	0.61 (0.63,0.58)	0.68 (0.70,0.66)	27675	0.48 (0.51,0.46)	0.61 (0.63,0.58)	0.68 (0.70,0.66)
Secondary school	67047	0.72 (0.75,0.69)	0.82 (0.85,0.79)	0.83 (0.85,0.81)	67047	0.72 (0.75,0.69)	0.82 (0.85,0.79)	0.83 (0.85,0.81)
Bachelors degree	41901	0.81 (0.85,0.78)	0.84 (0.87,0.81)	0.86 (0.88,0.84)	41901	0.81 (0.85,0.78)	0.84 (0.87,0.81)	0.86 (0.88,0.84)
Postgraduate degree	57570	-	-	-	57570	-	-	-
Father highest qualification								
No formal qualification	26712	0.65 (0.68,0.61)	0.73 (0.76,0.70)	0.82 (0.85,0.79)	26712	0.65 (0.68,0.61)	0.73 (0.76,0.70)	0.82 (0.85,0.79)
Secondary school	51177	0.86 (0.91,0.82)	0.91 (0.94,0.88)	0.90 (0.93,0.88)	51177	0.86 (0.91,0.82)	0.91 (0.94,0.88)	0.90 (0.93,0.88)
Bachelors degree	47388	0.99 (1.04,0.94)	0.98 (1.02,0.94)	1.06 (1.10,1.04)	47388	0.99 (1.04,0.94)	0.98 (1.02,0.94)	1.06 (1.10,1.04)
Postgraduate degree	39450	-	-	-	39450	-	-	-
Member of household receives benefit income								
No	159069	-	-	-	158679	-	-	-
Yes	51777	0.57 (0.59,0.55)	0.65 (0.66,0.63)	0.66 (0.67,0.65)	51720	0.56 (0.58,0.55)	0.64 (0.66,0.63)	0.66 (0.67,0.65)
Family circumstances								

Age of mother at child's birth								
<20	14313	0.48 (0.51,0.46)	0.56 (0.59,0.54)	0.64 (0.66,0.62)	14313	0.48 (0.51,0.46)	0.56 (0.59,0.54)	0.64 (0.66,0.62)
20-24	41889	0.63 (0.66,0.61)	0.69 (0.72,0.67)	0.75 (0.77,0.74)	41889	0.63 (0.66,0.61)	0.69 (0.72,0.67)	0.75 (0.77,0.74)
25-29	55800	0.83 (0.86,0.79)	0.88 (0.90,0.85)	0.88 (0.91,0.87)	55800	0.83 (0.86,0.79)	0.88 (0.90,0.85)	0.88 (0.91,0.87)
30-34	66297	-	-	-	66297	-	-	-
35+	58977	0.90 (0.93,0.87)	0.89 (0.92,0.86)	0.95 (0.97,0.93)	58974	0.90 (0.93,0.87)	0.89 (0.92,0.86)	0.95 (0.97,0.93)
Father on birth certificate								
No	12612	0.56 (0.59,0.53)	0.61 (0.64,0.59)	0.60 (0.62,0.57)	12612	0.56 (0.59,0.53)	0.61 (0.64,0.59)	0.60 (0.62,0.57)
Yes	224664	-	-	-	224664	-	-	-
Mother speaks English								
No	3483	0.81 (0.90,0.72)	1.00 (1.10,0.92)	0.56 (0.60,0.53)	3483	0.81 (0.90,0.72)	1.00 (1.10,0.92)	0.56 (0.60,0.53)
Yes	196248	-	-	-	196248	-	-	-
Housing								
Urban	224976	-	-	-	215775	-	-	-
Rural	36630	1.05 (1.09,1.01)	1.03 (1.06,1.00)	1.59 (1.61,1.54)	35838	0.93 (0.96,0.89)	0.95 (0.98,0.93)	1.54 (1.59,1.52)
Household size								
2-4 people	121098	-	-	-	120852	-	-	-
5-7 people	77961	0.74 (0.76,0.71)	0.75 (0.76,0.72)	0.76 (0.77,0.75)	77808	0.74 (0.76,0.71)	0.74 (0.76,0.72)	0.76 (0.77,0.75)
8+ people	11784	0.42 (0.44,0.40)	0.51 (0.53,0.49)	0.36 (0.37,0.34)	11742	0.42 (0.44,0.40)	0.51 (0.53,0.49)	0.36 (0.37,0.34)

Own home	112581	-	-	-	112458	-	-	-
Rented home	94146	0.56 (0.57,0.54)	0.63 (0.65,0.62)	0.71 (0.72,0.69)	93840	0.56 (0.58,0.54)	0.64 (0.65,0.63)	0.71 (0.72,0.70)
Number of residence changes age 0-4								
None	61761	-	-	-	62412	-	-	-
1	57459	2.86 (2.94,2.78)	2.13 (2.17,2.08)	1.33 (1.37,1.30)	47994	1.16 (1.22,1.12)	1.01 (1.04,0.98)	0.90 (0.92,0.88)
2	42891	2.86 (2.94,2.70)	2.00 (2.08,1.92)	1.25 (1.28,1.22)	31935	0.96 (1.00,0.92)	0.85 (0.88,0.81)	0.83 (0.85,0.81)
3	28653	2.33 (2.44,2.22)	1.67 (1.72,1.61)	1.15 (1.18,1.11)	20745	0.85 (0.90,0.81)	0.73 (0.76,0.70)	0.78 (0.81,0.76)
4	18810	2.04 (2.13,1.92)	1.41 (1.47,1.37)	1.08 (1.11,1.04)	32235	0.66 (0.68,0.63)	0.60 (0.62,0.58)	0.76 (0.79,0.75)
5+	30447	1.56 (1.61,1.49)	1.16 (1.20,1.12)	1.05 (1.09,1.03)	62412	1.37 (1.43,1.32)	1.18 (1.22,1.14)	0.99 (1.01,0.97)
Health status								
Mother smoking status								
Regular smoker	38457	0.56 (0.57,0.53)	0.63 (0.65,0.61)	0.78 (0.79,0.76)	38460	0.56 (0.57,0.53)	0.63 (0.65,0.61)	0.78 (0.79,0.76)
Ex smoker	45420	0.94 (0.98,0.90)	0.90 (0.93,0.88)	1.08 (1.10,1.05)	45420	0.94 (0.98,0.90)	0.90 (0.93,0.88)	1.08 (1.10,1.05)
Never smoked	111219	-	-	-	111219	-	-	-
Birthweight								
<2500g	14049	0.57 (0.60,0.55)	0.73 (0.76,0.70)	0.87 (0.90,0.84)	14049	0.57 (0.60,0.55)	0.73 (0.76,0.70)	0.87 (0.90,0.84)
2500-4000g	187242	-	-	-	187239	-	-	-
>4000g	34746	1.01 (1.05,0.97)	0.96 (0.99,0.93)	1.04 (1.06,1.01)	34749	1.01 (1.05,0.97)	0.96 (0.99,0.93)	1.04 (1.06,1.01)

Gestation								
<37 weeks	17922	0.60 (0.63,0.57)	0.76 (0.79,0.73)	0.88 (0.91,0.85)	17922	0.60 (0.63,0.57)	0.76 (0.79,0.73)	0.88 (0.91,0.85)
37-42 weeks	217128	-	-	-	217128	-	-	-
>42 weeks	1443	1.00 (1.19,0.85)	0.97 (1.11,0.84)	0.67 (0.75,0.61)	1443	1.00 (1.19,0.85)	0.97 (1.11,0.84)	0.67 (0.75,0.61)
Child referred for disability support assessment								
No	261408	-	-	-	247875	-	-	-
Yes	4473	0.46 (0.50,0.43)	0.46 (0.49,0.43)	0.61 (0.65,0.57)	4401	0.34 (0.37,0.32)	0.38 (0.40,0.36)	0.56 (0.60,0.53)
Number of quarters enrolled with GP age 0-4								
0-3	27360	0.07 (0.07,0.07)	0.09 (0.10,0.09)	0.24 (0.25,0.23)		0.16 (0.17,0.16)	0.20 (0.21,0.19)	0.42 (0.44, 0.41)
4-7	44112	0.48 (0.50,0.45)	0.50 (0.52,0.49)	0.81 (0.83,0.79)		0.53 (0.55,0.51)	0.54 (0.55,0.52)	0.83 (0.85, 0.81)
8-11	96006	0.75 (0.78,0.73)	0.78 (0.79,0.75)	0.98 (0.99,0.96)		0.76 (0.79,0.74)	0.78 (0.80, 0.76)	0.98 (1.00, 0.96)
12+	98406	-	-	-		-	-	-
Number of hospital admissions age 0-4								
None	104382	-	-	-	108081	-	-	-
1 to 2	104280	2.17 (2.22,2.13)	1.75 (1.82,1.72)	1.35 (1.37,1.32)	111288	1.32 (1.35,1.28)	1.23 (1.27,1.20)	1.14 (1.16,1.12)
3 to 5	21528	1.85 (1.92,1.79)	1.64 (1.72,1.59)	1.32 (1.35,1.27)	22668	1.06 (1.11,1.01)	1.11 (1.15,1.06)	1.09 (1.11,1.05)
6+	9834	1.23 (1.32,1.18)	1.19 (1.25,1.14)	1.12 (1.16,1.08)	10242	0.73 (0.77,0.69)	0.82 (0.86,0.78)	0.94 (0.98,0.91)

Total days in hospital age 0-4								
None	134751	-	-	-	141108	-	-	-
1 to 9	96537	1.92 (1.96,1.85)	1.59 (1.61,1.54)	1.27 (1.30,1.25)	102060	1.23 (1.27,1.20)	1.16 (1.19,1.14)	1.11 (1.12,1.09)
10 to 19	5022	1.28 (1.41,1.19)	1.22 (1.32,1.14)	0.98 (1.03,0.93)	5268	0.83 (0.91,0.77)	0.90 (0.96,0.84)	0.85 (0.90,0.81)
20+	3714	0.81 (0.88,0.75)	0.84 (0.91,0.78)	0.82 (0.88,0.77)	3843	0.53 (0.58,0.49)	0.63 (0.67,0.58)	0.72 (0.77,0.68)
Total number of ED visits age 0-4								
None	205911	-	-	-	215601	-	-	-
1 to 2	31854	1.20 (1.37,1.06)	0.96 (1.06,0.87)	0.63 (0.69,0.58)	34218	0.99 (1.02,0.95)	0.93 (0.95,0.90)	0.69 (0.71,0.68)
3+	2262	0.98 (1.01,0.96)	0.98 (1.00,0.96)	0.99 (1.01,0.98)	2457	0.85 (0.95,0.75)	0.76 (0.85,0.69)	0.58 (0.63,0.54)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4, 5
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7, 8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7, 8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-11
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-11
Bias	9	Describe any efforts to address potential sources of bias	*8, APPENDIX 2*
Study size	10	Explain how the study size was arrived at	7, 8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-11
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	12
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	8, APPENDIX 2
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	13, TABLE 1
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-11
		(b) Indicate number of participants with missing data for each variable of interest	8-11
Outcome data	15*	Report numbers of outcome events or summary measures	13, TABLES 1 AND 2
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	TABLE 2
		(*b*) Report category boundaries when continuous variables were categorized	8-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8, APPENDIX 2
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15, 16
Generalisability	21	Discuss the generalisability (external validity) of the study results	15, 16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	1

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

How Universal are Universal Pre-School Health Checks? An observational study using routine data from New Zealand's B4 School Check

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-025535.R1
Article Type:	Research
Date Submitted by the Author:	03-Oct-2018
Complete List of Authors:	Gibb, Sheree; University of Otago Wellington, Public Health; A Better Start National Science Challenge Milne, Barry; University of Auckland, Centre of Methods and Policy Application in the Social Sciences; University of Auckland Shackleton, Nichola; University of Auckland, Centre of Methods and Policy Application in the Social Sciences; A Better Start National Science Challenge Taylor, Barry; University of Otago, Department of the Dean; A Better Start National Science Challenge Audas, Richard; University of Otago Department of Women's and Children's Health; A Better Start National Science Challenge
Primary Subject Heading:	Public health
Secondary Subject Heading:	Health services research
Keywords:	healthcare disparities, data linkage, childhood intervention

How Universal are Universal Pre-School Health Checks? An observational study using routine data from New Zealand's B4 School Check

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Key words: healthcare disparities; data linkage; childhood intervention

Word count: 4383

Funding: This study was funded by A Better Start – National Science Challenge, New Zealand Ministry for Business, Innovation and Employment.

Disclaimer: Access to the data used in this study was provided by Statistics New Zealand under conditions designed to give effect to the security and confidentiality provisions of the Statistics Act 1975. The results presented in this study are the work of the authors, not Statistics NZ.

Abstract

Objectives: We aimed to estimate how many children were attending a universal pre-school health screen and to identify characteristics associated with non-participation.

Design: Analysis of population level linked administrative data.

Participants: Children were counted in the population of resident 4-year-olds for a given year if 1) they were ever resident in New Zealand, and 2) lived in NZ for at least 6 months during the reference year, 3) were alive at the end of the reference year, and either 4) appeared in any hospital (including emergency) admissions, community pharmaceutical dispensing, or GP enrolment datasets during the reference year, or 5) had a registered birth in New Zealand. We analysed 252,273 records over 4 years, from July 1st 2011 to June 30th 2015.

Results: We found that participation rates varied for each component of the B4 School Check (in 2014/15 91.8% for Vision and Hearing tests (VHT), 87.2% for nurse checks (including height, weight, oral health, SDQ, PEDS) and 62.1% for Teacher SDQ (SDQT)), but participation rates for all components increased over time. Māori and Pacific children were less likely to complete the checks than non-Māori and non-Pacific children (for VHT tests Māori OR=0.60 (0.61,0.58), Pacific OR=0.58 (0.60,0.56), for nurse checks Māori OR=0.63 (0.64,0.61), Pacific OR=0.67 (0.69,0.65), for SDQT Māori OR=0.76 (0.78,0.75), Pacific OR=0.37 (0.38,0.36)). Children from socioeconomically deprived areas, with younger mothers, from rented homes, residing in larger households, with worse health status, and with higher rates of residential mobility were less likely to participate in the B4 School Check than other children.

Conclusion: The patterns of non-participation suggest a reinforcing of existing disparities, whereby the children most in need are not getting the services they require. There needs to be

an increased effort by public health organizations, community and whānau/family to ensure that all children are tested and screened.

Strengths and limitations of this study

- Whole population sample of all children completing B4 School check over 4 years (N=252,273)
- Using linked data from different sectors provided information about a wide range of characteristics
- Only bivariate analyses were possible; sample loss due to missing data meant that multivariate analysis was not feasible

Introduction

Globally, a common practice in childhood development is to screen children to determine if there are any key developmental problems that need to be assessed (1). These screens typically check for problems relating to general health, including hearing, vision, height, weight and oral health. They also often screen for emotional, behavioural, or intellectual issues that might be evident (2). Hall and Stewart-Brown categorize four types of screening programmes: i) biochemical; ii) screening involving objective measures (such as height and weight, vision and hearing; iii) screening involving physical examination; and iv) screening involving understanding of child development (3).

In New Zealand, the screen is called the Before School Check (B4SC) and it is administered to four year olds. It is the final and most comprehensive in a series of eight free Well Child Tamariki Ora visits that children receive (4), and currently the only one for which comprehensive linked data are available to examine coverage. The B4SC was implemented in New Zealand starting in September 2008, although it was not universal until 2010. There are eight key developmental areas that are assessed: vision, hearing, oral health, general health, growth measurement, strengths and difficulties (SDQ) as reported by parents and teachers and a parental evaluation of development status (PEDS). If concerns are identified in any area, children are referred for further testing or intervention. The B4SC is administered by the Ministry of Health, which has set a target 90% participation rate across the country, with parents and guardians being notified of the B4SC via enrolment with a primary health organisation (PHO, organisations that provide primary care services (5)). The Ministry's data suggests they have been meeting their target

since 2013, but compliance falls short of 100% (6). Furthermore, not all children are registered with a PHO (95% of 0-4 year olds are registered (7)), and including unregistered children in the denominator will further reduce compliance rates.

This raises three concerns: First, that a non-trivial number of children are missing their checks. Second, that some children may not be registered with a PHO and as such, their parents are not notified that their child should attend a B4SC. And third, that these children may be more likely to be in higher risk categories for later health problems and could benefit from the referrals to interventions that accompany this screen. It is this final concern that is the focus of this study.

Evidence Preschool / School Entry Screening Participation

Across different universal health checks available to the adult populations of different countries certain patterns persist: those in poorer socioeconomic circumstances, with lower qualifications, and at greater risk of health problems are less likely to attend such checks (8-13).

The available evidence for universal health checks in childhood suggests a similar pattern (14-16). Wood et al considered the coverage of universal child health reviews in Scotland (15). They considered two cohorts of children, the first, born in 1998/99 were eligible for 5 health checks (10 days/6-8 weeks/8-9 months/22-24 months and 39-42 months) and a second cohort, born in 2007/08, were only eligible for the first two checks. They found that coverage rates of the 10-day check were very high in both cohorts (99%), but this declined as the children aged. For the

6-8 week review, coverage was between 94-95%, and for the 39-42 month review the coverage rates fell to 86%. There were clear deprivation gradients, with children living in the least deprived areas much more likely to have a health check than those in the most deprived areas, and these gradients increased substantially with increasing age and decreasing coverage. They conducted an audit on a subset of the areas included in the review (Glasgow and Fife). Consistent with the inverse care law (17) they found that children who missed the 6-8 week review were more likely to require additional health services and support in the future than those who attended the review.

Similarly, evidence from Denmark suggests that participation declines with age. Only 76% of eligible children attend the age 4 health screen. Child, parent and household level characteristics predicted attendance with children who had been hospitalised at least twice since birth, children of single, younger, less educated or immigrant parents, and children residing in low income households or living in institutions less likely to participate (16). Similarly in North Carolina children of mothers who were younger, less educated, black, and unmarried were also less likely to receive an adequate number of well child visits (14).

The overall aim of these universal checks is to identify children who are at risk of later problems and direct them towards interventions that will reduce this risk. The early identification of health and developmental issues increases the efficacy and cost effectiveness of treatment and lessens the risk of any potential comorbidities. However, evidence about whether or not childhood screening achieves this aim is mixed (18-20). Childhood screening relies on accurate identification of children at risk, and also on the availability of effective interventions or

treatments for at-risk children, which are not always available (19, 21). Regardless, universal checks are often the only instrument to identify children in need of additional services, who may otherwise be missed by the health system. Therefore, systematic differences in attendance highlight a crucial issue: those children most in need are missing out on vital services.

In New Zealand we are in a unique position to examine the characteristics of those not completing the B4SC. Many routinely collected government databases (including B4SC) are held in the Statistics New Zealand Integrated Data Infrastructure (IDI) and each individual is assigned a unique identifier which allows their records to be linked across data files. In this analysis we build a population cohort using birth records and immigration/emigration files to determine which four year-olds were in the country and eligible for the B4SC between July 1st 2011 to June 30th 2015, and then we examine the characteristics of those who do not get the B4SC.

The aim of this paper is to identify characteristics associated with non-participation in the B4SC by linking to deprivation, birth, census, health, disability and immunisation records, all of which are available in the IDI.

Methods

Study design

This study was an observational study using routine data from New Zealand's Integrated Data Infrastructure.

Data sources and linkage

All data were sourced from the Integrated Data Structure (22), a secure database containing anonymised microdata about individuals.

B4 School Check

The main outcome measures for this study were generates from B4 School Check data. The B4 School Check (B4SC) is a universal programme offered to all families in New Zealand with four-year-old children (23). If a child is enrolled with a primary health organisation a letter or email will be sent to parents inviting them to bring the child along for a B4SC. Parents can also request a check by approaching a general practitioner or other B4SC provider. The checks are carried out by registered nurses or nurse practitioners with experience in child health, with assistance from vision and hearing technicians (4). One component (SDQ-Teacher) is completed by a child's early childhood education (ECE) teacher, who receives the SDQ directly from the B4SC provider and is responsible for returning it to the provider (24). ECE coverage is high in New Zealand with more than 95% of children enrolled in ECE in the 6 months prior to starting school (25). The B4SC is undertaken in different locations including preschools, kōhanga reo, doctors' clinics and other community venues such as churches and marae, depending on the needs of the community. In some cases, parts of the B4 School Check are carried out in the child's home.

The percentage attending the B4SC was estimated as 79% in 2011/2012, 80% in 2012/2013, 91% in 2013/2014, 92% in 2014/15, and 92% in 2015-2016 (6). High coverage of vulnerable groups (Māori children and children from areas of high socioeconomic deprivation) is encouraged by linking a portion of District Health Board (DHB, see (26)) funding for B4SC to achieving a specified level of coverage for these groups. In the 2015/16 year the coverage for Māori children was 88% and for Pacific children it was 89% (27). For children from high deprivation areas the coverage was 93% (6). This paper uses data from B4 school checks completed between the fiscal years 2011/12 and 2014/15.

Other datasets

Datasets used to construct the other analysis variables for this study were: Census 2013; Ministry of Health PHO enrolment and hospital discharge datasets; source ranked ethnicity; address notification; SOCRATES; and birth registrations. More detail on the variables constructed from these datasets can be found in the 'other analysis variables' section below.

Study population

To identify the population of children eligible for a B4SC, annual populations of four-year-old children were constructed using methods developed previously for constructing populations from the Integrated Data Infrastructure (IDI) (28, 29). Children were included in the denominator population for a given year if they:

- Appeared in any hospital (including emergency) admissions, community pharmaceutical dispensing, or PHO enrolment datasets during the reference year; OR

- Had a NZ birth record.

The above population was then restricted to children who lived in NZ for at least 6 months during the reference year, were alive at the end of the reference year, were included in the IDI spine (which aims to cover an "ever-resident" population including all those who either were born in New Zealand, migrated to New Zealand, or paid tax in New Zealand (30)).

Over the four-year period we identified 288,753 children who had a health or birth record. Of those, 277,593 (96%) were in the IDI spine, and 252,273 of those (91%) were alive and resident in New Zealand at the end of their reference year and were used as the denominator population.

To examine whether the above criteria had an impact on study results we conducted a sensitivity analysis in which we replicated the analysis using two different definitions of the study population. The main conclusions of the study were the same across all replications. The detailed results of the sensitivity analysis can be found in Appendix 1.

Outcomes

B4SC completion

For the purposes of this study, B4SC was grouped into three components: Vision and Hearing Test (VHT) checks (vision and hearing); nurse checks (growth, dental, immunisation, Parents Evaluation of Developmental Status (PEDS), and Strengths and Difficulties Questionnaire (SDQ) Parent); and SDQ Teacher. These groupings were developed in consultation with the Ministry of Health and reflect the way in which the components are typically completed (vision and hearing checks are usually completed together by vision and hearing technicians, the nurse checks are

usually completed together, SDQ-Teacher is completed separately by a child's early childhood education teacher). In some regions these groups of checks are administered in separate visits; in other regions they are combined into a single visit. If a child had completed all checks within a component they were considered to have completed that component. B4SC coverage was calculated as the number of children completing a B4SC component divided by the total number of children in the population. Completion rates for the individual component checks can be found in Appendix 2.

Other analysis variables

Ethnicity

Ethnicity measures were taken from the source ranked ethnicity table in IDI. The table collates ethnicities that are reported to different administrative collections in IDI and ranks these sources to provide an ethnic profile for each individual. Ranking is based on how closely the ethnicities reported for an individual in the administrative source match those reported in the census (census records have highest priority and 84.3% of the study population had ethnicity sourced from census, followed by birth records (13.9%), followed by health (1.7%))(31). From this we constructed four dichotomous ethnicity variables representing whether or not children were recorded as identifying with each of the following major ethnic groups: Māori; Pacific; Asian; European. Individuals could belong to none, one, or more than one of these ethnic groups. Identifying as more than one ethnicity is common in New Zealand (32) and 23.9% of the current sample belonged to multiple ethnic groups.

Socioeconomic deprivation

NZ Deprivation Score (NZDep) was calculated using the standard 2013 NZDep concordance (33) and the child's meshblock (small geographic area typically containing 30-80 dwellings (34)) of usual residence at the time of the 4th birthday, or the first meshblock recorded within 12 months after the date of the 4th birthday if no meshblock was recorded prior to that. Each meshblock was assigned a decile from 1 (least deprived) to 10 (most deprived). These were then grouped into quintiles.

Urbanicity

The child's meshblock of usual residence was also used to define urbanicity. The standard classification of urban/rural areas in New Zealand (35) is a five-point scale: 1) Main urban (centred on a city or major urban area, population of at least 30,000), 2) secondary urban (centred on larger regional centres, population 10,000-29,999), 3) minor urban (centred around smaller towns, population 1,000–9,999), 4) rural centre (population 300-999) and 5) other rural (population <300). These were collapsed into two groups: urban (main urban, secondary urban, and minor urban area) and rural (rural centre and other rural).

Residence changes

The total number of different addresses lived at from birth to fourth birthday (minus one to give the number of changes) was calculated from the address notification table in IDI which collates address updates reported to data providers.

Hospitalisations

The following variables were obtained from hospital records: total number of hospital admissions (excluding the child's birth and any emergency department visits that did not result in hospital admission) from birth to fourth birthday; the total number of days spent in hospital for those visits; total number of emergency department visits from birth to fourth birthday.

GP enrolment

The extent to which a child had continuous enrolment with a general practitioner was estimated by counting the number of quarters in which a child was enrolled with a Primary Health Organisation (umbrella organisations for general practitioners) from birth to fourth birthday.

Disability

Children who received a referral to Disability Support Services before their fourth birthday were classified as having a disability.

Information from birth record

Birth records were available for 94.1% of the total sample. The following variables were obtained from the child's birth record: the child's birth weight, in grams; gestational age, categorised into <37 weeks, 37-42 weeks, and >42 weeks; whether or not a father was recorded on the child's birth certificate; age of the child's mother at the time of the child's birth, grouped into under 20; 20-24; 25-29; 30-34; 35 and over.

Variables from census records

Additional variables were obtained by linking to census records. Household variables were obtained by linking to the household form connected to the child's census record, 82.9% of children had census household information available. Mother and father variables were obtained by first linking to the child's birth record to identify mother and father, and then linking to census records for the mother and father. 79.8% of children had mother census information available; 68.5% had father census information available. All census variables are recorded as at Census day (5 March 2013). The variables from Census were: size of household (including child), grouped into: 2 to 4 people; 5 to 7 people; 8 or more people; whether the dwelling was rented or owned (including those held in family trusts); whether or not any member of the child's household received benefit income in the year to 5 March 2013; whether or not the child's mother spoke enough English to have a conversation about everyday things; the highest qualification of the child's mother and father at the time of the 2013 census, classified into: no formal qualifications; high school qualifications; tertiary qualification below Bachelor degree; Bachelor degree or higher; the current smoking status of the child's mother at the time of the census, classified into: current regular smoker; ex-smoker; never smoked.

Analysis

All analyses were conducted using SAS Enterprise Guide version 9 within the secure data lab environment. First, we constructed the population, and calculated rates of those who completed components (VHT, nurse checks, SDQT) of the B4SC. Second, we compared the characteristics of those who did not complete a component compared to those who did by

fitting logistic regression models in which B4SC completion was modelled as a function of the relevant predictor. Odds ratios and 95% confidence intervals were calculated from the logistic regression coefficients.

Patient and public involvement

Patients and public were not involved in the design or conduct of this study.

Results

Table 1 shows the total number of children in the denominator (eligible) population for each year, and the number and percentage of children who completed the VHT, nurse and SDQT components of the B4SC, by year. In all years, completion was highest for the VHT component and lowest for the SDQ Teacher component. Approximately 52% to 62% of children completed the SDQ Teacher component, compared to 78% to 87% for the nurse components and 86% to 91% for the VHT components. Coverage was lowest in 2011/12 and highest in 2014/15.

INSERT TABLE 1 HERE

Tables 2 and 3 show the associations between completion of each B4SC component for 2011/12 to 2014/15 (all years combined), and a range of characteristics. Sociodeomgraphic characteristics are reported in Table 1 and health and perinatal characteristics in Table 2. The tables show the number and percentage of children completing each B4SC component, the odds ratio and 95% confidence intervals.

Most of the sociodemographic characteristics presented in Table 1 were significantly associated with B4SC completion. Children were more likely to complete a check if they: were of European (compared to not European) or Asian (compared to not Asian) ethnicity; had fewer siblings; came from areas of lower socioeconomic deprivation; had a mother with a Bachelor degree; had mothers aged 30-34; lived in a home that was owned rather than rented; lived in a smaller (2-4 person) household; and lived in a household that does not receive benefit income.

The health and perinatal characteristics presented in Table 2 were all significantly associated with B4SC completion. Children were more likely to complete a B4SC if they: had a mother that had never smoked; weighed between 2500 and 4000 grams at birth; had a gestational age of between 37 and 42 weeks; were not referred for disability support; spent more time enrolled with a GP; had lower numbers of hospital and emergency department admissions and spent fewer days in hospital.

INSERT TABLE 2 HERE

Discussion

Our results demonstrate that Māori and Pacific children, those in poorer socioeconomic circumstances, and with poorer health are less likely to complete the B4SC. Children living in areas of higher socioeconomic deprivation, without a father named on the birth certificate, with mothers and fathers with lower levels of education, living in households with 5 or more people, having multiple changes in residence in the early years of life and living in rental accommodation have a lower likelihood of B4SC completion. Children with indicators of poor health outcomes including having a mother who smokes and having a low birth weight also have a lower likelihood of B4SC completion. Given that these factors tend to be associated with poorer child health outcomes (36, 37), our results paint a consistent pattern, demonstrating that across a wide range of measures of vulnerability, those children who would potentially most benefit from a B4SC screen and the referrals to interventions are less likely to participate.

A strength of this study is the large, linked dataset that was used (the Integrated Data Infrastructure, IDI). The IDI is a whole population data source and therefore it allows us to include children who are often excluded from other analyses, such as those not in regular contact with health services. Furthermore, the large number of data sources included in the IDI allows us to examine a wider range of characteristics than would be available in any single source.

While this study is novel, and provides vital information for service providers, all of the analyses presented in this paper are bivariate. It is likely that children who are disadvantaged in one area are also at a disadvantage in other areas (that is, the predictors of B4SC completion are correlated). Multivariate analysis would provide more detailed information about the joint or relative impact of different predictors on B4 School check completion. However, to run multivariate analysis we would have to restrict our sample to children born in NZ, with a mother and father

who completed 2013 census. These restrictions would reduce the sample to less than 70% of the total sample and would exclude all migrants, making the results difficult to generalise to the whole population. For this reason we have chosen not to undertake multivariate analysis in this paper.

Our findings are consistent with existing literature on the coverage of child health checks (14-16), and provide further support for the inverse care law – that those with the greatest need are the least likely to seek services (17). There is currently very little research in this area for child health screens, but the application of the inverse care law is a consistent finding among free health checks for the adult population (8-13). However, the reasons why people most in need do not attend are not well understood, and there is a need for qualitative research investigating why parents are not taking children to free health checks.

Several potential explanations for non-attendance at adult health checks have been put forward that may be applicable to child health checks including lack of awareness, time constraints and access issues (10), and misunderstanding the purpose/scepticism. Focus groups conducted with low income Māori and Pacific parents have identified concerns about relevance of the B4SC checks, children and parents being judged, and language and cultural understanding as potential barriers to participation (38). Lack of awareness of the checks was also identified as a problem, and this may be a particular issue for children who are not enrolled on the PHO system (5% of children) or who have incorrect address information and thus do not receive the invitation letter. Access could also be an issue with many of the B4 School checks being carried out by Plunket or other health services which are only open during normal office hours, and not at weekends (38, 39). Therefore, households where both parents work, or single-parent working households will not easily be able to attend. Furthermore, for less densely populated regions in New Zealand there are fewer centres offering B4 School checks, compared to more densely populated regions such as

Auckland, Wellington or Christchurch (39), meaning it is less convenient to attend. Scepticism about the value of attending and the purpose of the screens is likely to differ by ethnic group, as research persistently demonstrates that Māori receive a poorer quality and slower service, and are less likely to receive appropriate levels of care (40-42). There are similar findings for Pacific peoples also (43-45). Therefore these groups may be less trusting of the New Zealand health system (46).

Socioeconomic and ethnic inequalities in health-seeking and health outcomes within New Zealand are well documented for both the adult and child population (44, 45, 47). A long standing objective of the New Zealand government is to reduce health and socio-economic disparities, particularly for Māori and Pacific families. Patterns of participation at the B4SC could be reinforcing existing ethnic and socioeconomic disparities. Early intervention is one means of reducing inequities (48, 49). Although evidence for the effectiveness of childhood screening is mixed, at present it appears that any potential benefits that do result from the B4SC will be unevenly distributed across ethnic and socioeconomic groups. Improving B4SC participation would be a cost-effective path towards converging outcomes and would ensure that any benefits from the screen are reaching children who are most at risk of later health concerns.

Although 100% attendance in the B4SC is unlikely, we believe that a greater effort is required to reach the most vulnerable families to ensure that more children who would benefit from the B4SC will get access to the interventions that arise from it. This will require greater outreach and public awareness, but also examining whether access and cultural relevance of the B4SC could be improved.

An area where there has been some success in getting increased services to hard-to-reach populations has been through mobile programs and services (50, 51). For example, in America

community health vans have shown success in reaching underserved populations such a low-income minority groups and immigrants for a range of health needs including earlier access to prenatal care and disease prevention screening (52-54). The Family Van run by Harvard Medical School offers a diverse range of health services, and has saved an estimated $2.8 million in avoided emergency room visits over the last 5 years with an estimated $23 saving per $1 spent (55). In addition, direct contact with those not participating should be considered with a greater push to ensure that those with characteristics of vulnerability are encouraged to attend. Further research is necessary on barriers to attendance identified and remedial action taken.

We have not followed children to determine whether missing a B4SC does in fact have an impact on later life outcomes, and this clearly needs to be assessed. We plan to address this question in future work, although the limited time series for the B4SC means that we will only be able to examine outcomes up to age 15.

Conclusion

Using a rich and diverse range of measures, we find that children with indicators of socioeconomic deprivation or poor health are less likely to participate in the B4SC and as such they may miss referrals for programs and interventions that may increase their readiness to enter school. We believe the patterns we observe in B4SC participation suggest a potential reinforcing of existing inequalities and require increased effort to ensure that all children are tested and screened, and that those with the greatest need get access to health services, programmes and interventions.

Footnotes

Contributorship statement

RA, BM, BT and SG conceived the study. SG extracted data and did the main data analysis. NS provided statistical advice. All authors wrote and reviewed the manuscript, gave critical feedback and approved the final version for publication.

Competing interests

None.

Data sharing statement

Due to privacy regulations around the Integrated Data Infrastructure, data from this study are not available for sharing.

Ethical approval: This study was approved by the University of Otago Human Ethics Committee (ref D16/088).

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Table 1. Percentage of children completing B4SC components, by year

Fiscal year	N	N (%) VHT[a] complete	N (%) nurse[b] checks complete	N (%) SDQ[c] Teacher complete
2011/12	63,714	54,924 (86.2)	49,986 (78.5)	33,690 (52.9)
2012/13	62,664	55,344 (88.5)	50,814 (81.4)	35,433 (57.3)
2013/14	63,372	57,294 (90.5)	54,183 (85.6)	37,881 (60.0)
2014/15	62,529	57,282 (91.8)	54,348 (87.2)	38,379 (62.1)

[a] VHT = vision and hearing checks

[b] Nurse = dental, growth, immunisations, PEDS (Parent Evaluation of Developmental Status), SDQ-P (Strengths and difficulties questionnaire – Parent) check

[c] SDQ = Strengths and Difficulties Questionnaire

Table 2. Percentage of children completing B4SC, and odds ratios for completing, by sociodemographic, family and housing characteristics

	N (%)	N (%) complete			OR (95% CI)		
		VHT[a]	Nurse[b] checks	SDQ[c] Teacher	VHT	Nurse checks	SDQ Teacher
Sex							
Male	129,831 (51.5)	115,611 (89.0)	107,565 (82.9)	74,754 (57.6)	0.98 (1.01,0.96)	0.98 (1.00,0.96)	1.00 (1.01,0.98)
Female	122,439 (48.5)	109,227 (89.2)	101,766 (83.1)	70,629 (57.7)	-	-	-
missing	0 (0.0)						
Ethnicity							
Māori	71,196 (28.2)	60,714 (85.3)	55,491 (77.9)	37,575 (52.8)	0.60 (0.61,0.58)	0.63 (0.64,0.61)	0.76 (0.78,0.75)
Pacific	37,857 (15.0)	31,788 (84.0)	29,436 (77.8)	14,004 (37.0)	0.58 (0.60,0.56)	0.67 (0.69,0.65)	0.37 (0.38,0.36)
Asian	30,825 (12.2)	28,116 (91.2)	26,745 (86.8)	16,110 (52.3)	1.30 (1.35,1.25)	1.39 (1.45,1.35)	0.78 (0.80,0.76)
European	173,235 (68.7)	157,269 (90.8)	146,526 (84.6)	109,842 (63.4)	1.67 (1.72,1.64)	1.41 (1.45,1.39)	2.13 (2.17,2.08)
missing	0 (0.0)						
Number of siblings at time of birth							

0	123,123 (48.8)	110,223 (89.5)	103,509 (84.1)	71,829 (58.3)	-	-	-
1	70,626 (28.0)	64,260 (91.0)	59,877 (84.8)	42,615 (60.3)	1.18 (1.22,1.15)	1.05 (1.09,1.03)	1.09 (1.11,1.06)
2+	43,527 (17.3)	37,413 (86.0)	34,053 (78.2)	22,782 (52.3)	0.71 (0.74,0.69)	0.68 (0.70,0.66)	0.78 (0.80,0.77)
missing	15,003 (5.9)						
Socioeconomic deprivation							
NZDep quintile							
1 (least deprived)	50,520 (20.0)	46,584 (92.2)	43,530 (86.2)	32,199 (63.7)	-	-	-
2	46,323 (18.4)	42,150 (91.0)	39,282 (84.8)	28,182 (60.8)	0.85 (0.89,0.81)	0.89 (0.93,0.86)	0.88 (0.91,0.86)
3	45,672 (18.1)	41,145 (90.1)	38,199 (83.6)	27,810 (60.9)	0.77 (0.80,0.74)	0.82 (0.85,0.79)	0.88 (0.91,0.86)
4	47,043 (18.6)	41,736 (88.7)	38,895 (82.7)	27,423 (58.3)	0.66 (0.69,0.64)	0.77 (0.79,0.74)	0.79 (0.81,0.78)
5 (most deprived)	61,854 (24.5)	52,848 (85.4)	49,080 (79.3)	29,502 (47.7)	0.50 (0.52,0.48)	0.62 (0.64,0.60)	0.52 (0.53,0.51)
missing	867 (0.3)						
Mother's highest qualification							
No formal qualifications	27,672 (11.0)	24,012 (86.8)	22,452 (81.1)	15,213 (55.0)	0.48 (0.51,0.46)	0.61 (0.63,0.58)	0.68 (0.70,0.66)

Secondary school	67,047 (26.6)	60,861 (90.8)	57,180 (85.3)	40,173 (59.9)	0.72 (0.75,0.69)	0.82 (0.85,0.79)	0.83 (0.85,0.81)
Tertiary qualification below Bachelor degree	41,901 (16.6)	38,430 (91.7)	35,868 (85.6)	25,452 (60.7)	0.81 (0.85,0.78)	0.84 (0.87,0.81)	0.86 (0.88,0.84)
Bachelor degree or higher	57,570 (22.8)	53,631 (93.2)	50,442 (87.6)	36,972 (64.2)	-	-	-
missing	58,089 (23.0)						
Father highest qualification							
No formal qualification	26,712 (10.6)	23,784 (89.0)	22,251 (83.3)	15,549 (58.2)	0.65 (0.68,0.61)	0.73 (0.76,0.70)	0.82 (0.85,0.79)
Secondary school	51,177 (20.3)	46,866 (91.6)	44,094 (86.2)	30,960 (60.5)	0.86 (0.91,0.82)	0.91 (0.94,0.88)	0.90 (0.93,0.88)
Tertiary qualification below Bachelor degree	47,391 (18.8)	43,878 (92.6)	41,253 (87.0)	30,579 (64.5)	0.99 (1.04,0.94)	0.98 (1.02,0.94)	1.06 (1.10,1.04)
Bachelor degree or higher	39,447 (15.6)	36,546 (92.6)	34,413 (87.2)	24,840 (63.0)	-	-	-
missing	87,552 (34.7)						
Member of household receives benefit income							
No	158,679 (62.9)	147,216 (92.8)	138,420 (87.2)	100,071 (63.1)	-	-	-
Yes	51,720 (20.5)	45,438 (87.9)	42,093 (81.4)	27,339 (52.9)	0.56 (0.58,0.55)	0.64 (0.66,0.63)	0.66 (0.67,0.65)

missing	41,880 (16.6)						
Family circumstances							
Age of mother at child's birth							
<20	14,310 (5.7)	11,910 (83.2)	10,983 (76.8)	7,104 (49.6)	0.48 (0.51,0.46)	0.56 (0.59,0.54)	0.64 (0.66,0.62)
20-24	41,889 (16.6)	36,333 (86.7)	33,624 (80.3)	22,518 (53.8)	0.63 (0.66,0.61)	0.69 (0.72,0.67)	0.75 (0.77,0.74)
25-29	55,800 (22.1)	49,950 (89.5)	46,698 (83.7)	32,247 (57.8)	0.83 (0.86,0.79)	0.88 (0.90,0.85)	0.88 (0.91,0.87)
30-34	66,297 (26.3)	60,441 (91.2)	56,631 (85.4)	40,233 (60.7)	-	-	-
35+	58,977 (23.4)	53,259 (90.3)	49,500 (83.9)	35,121 (59.6)	0.90 (0.93,0.87)	0.89 (0.92,0.86)	0.95 (0.97,0.93)
missing	15,006 (5.9)						
Father on birth certificate							
No	196,248 (77.8)	10,467 (83.0)	9,567 (75.9)	5,763 (45.7)	0.56 (0.59,0.53)	0.61 (0.64,0.59)	0.60 (0.62,0.57)
Yes	3,483 (1.4)	201,429 (89.7)	187,872 (83.6)	131,463 (58.5)	-	-	-
missing	52,548 (20.8)						

Mother speaks English							
No	3,483 (1.4)	3,102 (89.1)	2,973 (85.4)	1,617 (46.4)	0.81 (0.90,0.72)	1.00 (1.10,0.92)	0.56 (0.60,0.53)
Yes	196,248 (77.8)	178,578 (91.0)	167,448 (85.3)	119,013 (60.6)	-	-	-
missing	52,548 (20.8)						
Housing							
Urban	35,838 (14.2)	31,767 (88.6)	29,565 (82.5)	23,832 (66.5)	-	-	-
Rural	215,775 (85.5)	192,864 (89.4)	179,577 (83.2)	121,410 (56.3)	0.93 (0.96,0.89)	0.95 (0.98,0.93)	1.54 (1.59,1.52)
missing	666 (0.3)						
Household size							
2-4 people	120,849 (47.9)	112,266 (92.9)	105,930 (87.7)	77,817 (64.4)	-	-	-
5-7 people	77,808 (30.8)	70,464 (90.6)	65,388 (84.0)	44,976 (57.8)	0.74 (0.76,0.71)	0.74 (0.76,0.72)	0.76 (0.77,0.75)
8+ people	11,739 (4.7)	9,921 (84.5)	9,195 (78.3)	4,617 (39.3)	0.42 (0.44,0.40)	0.51 (0.53,0.49)	0.36 (0.37,0.34)
missing	41,883 (16.6)						

Own home	112,458 (44.6)	105,333 (93.7)	99,384 (88.4)	72,561 (64.5)	-	-	-
Rented home	93,840 (37.2)	83,745 (89.2)	77,823 (82.9)	52,911 (56.4)	0.56 (0.58,0.54)	0.64 (0.65,0.63)	0.71 (0.72,0.70)
missing	45,981 (18.2)						
Number of residence changes age 0-4							
None	52,602 (20.9)	47,184 (89.7)	44,745 (85.1)	32,124 (61.1)	-	-	-
1	55,359 (21.9)	51,327 (92.7)	48,315 (87.3)	33,813 (61.1)	1.47 (1.52,1.41)	1.20 (1.25,1.16)	1.00 (1.02,0.98)
2	42,087 (16.7)	38,481 (91.4)	35,949 (85.4)	24,696 (58.7)	1.22 (1.28,1.18)	1.03 (1.06,0.99)	0.90 (0.93,0.88)
3	28,320 (11.2)	25,299 (89.3)	23,397 (82.6)	15,963 (56.4)	0.96 (1.01,0.92)	0.83 (0.87,0.80)	0.83 (0.85,0.80)
4	18,675 (7.4)	16,407 (87.9)	14,937 (80.0)	10,236 (54.8)	0.83 (0.88,0.79)	0.70 (0.73,0.67)	0.78 (0.80,0.75)
5+	30,282 (12.0)	25,599 (84.5)	23,181 (76.6)	16,419 (54.2)	0.63 (0.65,0.60)	0.57 (0.60,0.55)	0.76 (0.78,0.74)
missing	24,957 (9.9)						

Note: As individuals can identify as multiple ethnicities, counts for ethnic groups will sum to greater than the count for the total population. The reference groups for ethnicities are people not identifying with that ethnic group (for example, Māori is compared to non-Māori).

[a] VHT = vision and hearing checks

[b] Nurse = dental, growth, immunisations, PEDS (Parent Evaluation of Developmental Status), SDQ-P (Strengths and difficulties questionnaire – Parent)

check

[c] SDQ = Strengths and Difficulties Questionnaire

Table 3. Percentage of children completing B4SC, and odds ratios for completing, by perinatal and health characteristics

		% complete			OR (95% CI)		
	N	VHT[a]	Nurse[b] checks	SDQ[c] Teacher	VHT	Nurse checks	SDQ Teacher
Mother smoking status							
Regular smoker	38,460 (15.2)	33,366 (86.8)	31,026 (80.7)	21,240 (55.2)	0.56 (0.57,0.53)	0.63 (0.65,0.61)	0.78 (0.79,0.76)
Ex smoker	45,420 (18.0)	41,670 (91.7)	38,925 (85.7)	28,647 (63.1)	0.94 (0.98,0.90)	0.90 (0.93,0.88)	1.08 (1.10,1.05)
Never smoked	111,219 (44.1)	102,540 (92.2)	96,642 (86.9)	68,214 (61.3)	-	-	-
missing	57,180 (22.7)						
Birthweight							
<2500g	14,049 (5.6)	11,751 (83.6)	11,112 (79.1)	7,680 (54.7)	0.57 (0.60,0.55)	0.73 (0.76,0.70)	0.87 (0.90,0.84)
2500-4000g	187,239 (74.2)	168,387 (89.9)	156,939 (83.8)	108,762 (58.1)	-	-	-
>4000g	34,746 (13.8)	31,287 (90.0)	28,947 (83.3)	20,496 (59.0)	1.01 (1.05,0.97)	0.96 (0.99,0.93)	1.04 (1.06,1.01)
missing	16,245 (6.4)						
Gestation							

<37 weeks	17,925 (7.1)	15,105 (84.3)	14,256 (79.5)	9,888 (55.2)	0.60 (0.63,0.57)	0.76 (0.79,0.73)	0.88 (0.91,0.85)
37-42 weeks	217,128 (86.1)	195,228 (89.9)	181,734 (83.7)	126,483 (58.3)	-	-	-
>42 weeks	1,443 (0.6)	1,299 (90.0)	1,200 (83.2)	0,696 (48.2)	1.00 (1.19,0.85)	0.97 (1.11,0.84)	0.67 (0.75,0.61)
missing	15,783 (6.3)						
Child referred for disability support assessment							
No	247,878 (98.3)	221,568 (89.4)	206,451 (83.3)	143,463 (57.9)	-	-	-
Yes	4,401 (1.7)	3,270 (74.3)	2,880 (65.4)	1,917 (43.6)	0.34 (0.37,0.32)	0.38 (0.40,0.36)	0.56 (0.60,0.53)
missing	0 (0.0)						
Number of quarters enrolled with GP age 0-4							
0-3	9,438 (3.7)	5,328 (56.5)	4,464 (47.3)	2,826 (29.9)	0.10 (0.11,0.10)	0.13 (0.13,0.12)	0.29 (0.30,0.27)
4-7	37,671 (14.9)	32,592 (86.5)	29,547 (78.4)	20,919 (55.5)	0.52 (0.54,0.50)	0.52 (0.54,0.51)	0.83 (0.85,0.81)
8-11	92,856 (36.8)	83,955 (90.4)	78,396 (84.4)	55,284 (59.5)	0.76 (0.79,0.74)	0.78 (0.80,0.76)	0.98 (1.00,0.96)

12+	97,800 (38.8)	90,510 (92.5)	85,527 (87.5)	58,638 (60.0)	-	-	-
missing	14,505 (5.7)						
Number of hospital admissions age 0-4							
None	93,474 (37.1)	83,109 (88.9)	77,238 (82.6)	53,415 (57.1)	-	-	-
1 to 2	102,696 (40.7)	93,810 (91.3)	87,636 (85.3)	61,803 (60.2)	1.32 (1.35,1.28)	1.22 (1.25,1.19)	1.14 (1.15,1.11)
3 to 5	21,390 (8.5)	19,101 (89.3)	17,937 (83.9)	12,633 (59.1)	1.04 (1.09,0.99)	1.09 (1.14,1.05)	1.09 (1.11,1.05)
6+	9,762 (3.9)	8,277 (84.8)	7,707 (78.9)	5,397 (55.3)	0.69 (0.74,0.65)	0.79 (0.83,0.75)	0.93 (0.97,0.89)
missing	24,957 (9.9)						
Total days in hospital age 0-4							
None	123,231 (48.8)	110,022 (89.3)	102,492 (83.2)	71,280 (57.8)	-	-	-
1 to 9	95,478 (37.8)	86,991 (91.1)	81,243 (85.1)	57,501 (60.2)	1.23 (1.27,1.19)	1.15 (1.18,1.12)	1.10 (1.12,1.09)
10 to 19	4,953 (2.0)	4,323 (87.3)	4,041 (81.6)	2,664 (53.8)	0.83 (0.90,0.76)	0.90 (0.96,0.83)	0.85 (0.90,0.80)
20+	3,660 (1.5)	2,961 (80.9)	2,742 (74.9)	1,809 (49.4)	0.51 (0.55,0.47)	0.61 (0.65,0.56)	0.71 (0.76,0.67)

missing	24,957 (9.9)						
Total number of ED visits age 0-4							
None	193,905 (76.9)	174,354 (89.9)	162,942 (84.0)	116,460 (60.1)	-	-	-
1 to 2	31,173 (12.4)	27,960 (89.7)	25,791 (82.7)	15,759 (50.6)	0.97 (1.01,0.93)	0.91 (0.94,0.88)	0.68 (0.69,0.66)
3+	2,244 (0.9)	1,980 (88.2)	1,788 (79.7)	1,032 (46.0)	0.84 (0.96,0.74)	0.75 (0.83,0.68)	0.56 (0.61,0.52)
missing	24,957 (9.9)						

Note: As individuals can identify as multiple ethnicities, counts for ethnic groups will sum to greater than the count for the total population. The reference groups for ethnicities are people not identifying with that ethnic group (for example, Māori is compared to non-Māori).

[a] VHT = vision and hearing checks

[b] Nurse = dental, growth, immunisations, PEDS (Parent Evaluation of Developmental Status), SDQ-P (Strengths and difficulties questionnaire – Parent) check

[c] SDQ = Strengths and Difficulties Questionnaire

Appendix 1

Sensitivity analysis

The table below shows the effects of:

1. Changing the criteria for inclusion in the population (column 1). In the main analyses, children were included in the population if they were in the IDI spine AND had health or birth records. Column 1 of the table below shows the results when the population was defined as children who were in the IDI spine OR had birth or health records.

2. Changing the overseas time cut-off for exclusion from the residential mobility and hospitalisation analyses (column 2, differences only apply to hospitalisation and meshblock change variables). In the main analyses, children were excluded if they had spent more than a year overseas. Column 2 of the table below shows the results if all children were included regardless of the amount of time spent overseas.

	Different population				Different overseas cut-off			
		OR (95% CI)				OR (95% CI)		
	N	VHT incomplete	Nurse checks incomplete	SDQ Teacher incomplete	N	VHT incomplete	Nurse checks incomplete	SDQ Teacher incomplete
Sex								
Male	136896	0.98 (1.01,0.96)	0.98 (1.00,0.96)	0.99 (1.01,0.98)	129834	0.98 (1.01,0.96)	0.98 (1.00,0.96)	1.00 (1.01,0.98)
Female	128967	-	-	-	122439	-	-	-
Ethnicity								
Māori	73092	0.76 (0.79,0.75)	0.74 (0.75,0.72)	0.81 (0.82,0.79)	71196	0.60 (0.61,0.58)	0.63 (0.64,0.61)	0.76 (0.78,0.75)
Pacific	39903	0.60 (0.62,0.59)	0.68 (0.69,0.66)	0.38 (0.39,0.37)	37857	0.58 (0.60,0.56)	0.67 (0.69,0.65)	0.37 (0.38,0.36)
Asian	33039	1.09 (1.12,1.04)	1.20 (1.23,1.16)	0.76 (0.78,0.75)	30825	1.30 (1.35,1.25)	1.39 (1.45,1.35)	0.78 (0.80,0.76)
European	180345	1.72 (1.75,1.69)	1.49 (1.52,1.47)	2.13 (2.17,2.13)	173232	1.67 (1.72,1.64)	1.41 (1.45,1.39)	2.13 (2.17,2.08)
	136896	0.98 (1.01,0.96)	0.98 (1.00,0.96)	0.99 (1.01,0.98)	129834	0.98 (1.01,0.96)	0.98 (1.00,0.96)	1.00 (1.01,0.98)
Number of siblings at time of birth								
0	123123	-	-	-	123126	-	-	-
1	70626	1.18 (1.22,1.15)	1.05 (1.09,1.03)	1.09 (1.11,1.06)	70629	1.18 (1.22,1.15)	1.05 (1.09,1.03)	1.09 (1.11,1.06)
2+	43527	0.71 (0.74,0.69)	0.68 (0.70,0.66)	0.78 (0.80,0.77)	43527	0.71 (0.74,0.69)	0.68 (0.70,0.66)	0.78 (0.80,0.77)
Socioeconomic deprivation								
NZDep quintile								
1 (least deprived)	52995	-	-	-	50517			
2	48081	0.89 (0.93,0.86)	0.92 (0.95,0.88)	0.89 (0.92,0.87)	46326	0.85 (0.89,0.81)	0.89 (0.93,0.86)	0.88 (0.91,0.86)

3	47283	0.82 (0.85,0.79)	0.85 (0.88,0.82)	0.89 (0.92,0.88)	45672	0.77 (0.80,0.74)	0.82 (0.85,0.79)	0.88 (0.91,0.86)
4	48720	0.72 (0.75,0.69)	0.79 (0.82,0.77)	0.81 (0.83,0.79)	47043	0.66 (0.69,0.64)	0.77 (0.79,0.74)	0.79 (0.81,0.78)
5 (most deprived)	64308	0.54 (0.56,0.53)	0.64 (0.66,0.62)	0.53 (0.54,0.52)	61854	0.50 (0.52,0.48)	0.62 (0.64,0.60)	0.52 (0.53,0.51)
Mother highest qualification								
No formal qualifications	27672	0.48 (0.51,0.46)	0.61 (0.63,0.58)	0.68 (0.70,0.66)	27675	0.48 (0.51,0.46)	0.61 (0.63,0.58)	0.68 (0.70,0.66)
Secondary school	67047	0.72 (0.75,0.69)	0.82 (0.85,0.79)	0.83 (0.85,0.81)	67047	0.72 (0.75,0.69)	0.82 (0.85,0.79)	0.83 (0.85,0.81)
Bachelors degree	41901	0.81 (0.85,0.78)	0.84 (0.87,0.81)	0.86 (0.88,0.84)	41901	0.81 (0.85,0.78)	0.84 (0.87,0.81)	0.86 (0.88,0.84)
Postgraduate degree	57570	-	-	-	57570	-	-	-
Father highest qualification								
No formal qualification	26712	0.65 (0.68,0.61)	0.73 (0.76,0.70)	0.82 (0.85,0.79)	26712	0.65 (0.68,0.61)	0.73 (0.76,0.70)	0.82 (0.85,0.79)
Secondary school	51177	0.86 (0.91,0.82)	0.91 (0.94,0.88)	0.90 (0.93,0.88)	51177	0.86 (0.91,0.82)	0.91 (0.94,0.88)	0.90 (0.93,0.88)
Bachelors degree	47388	0.99 (1.04,0.94)	0.98 (1.02,0.94)	1.06 (1.10,1.04)	47388	0.99 (1.04,0.94)	0.98 (1.02,0.94)	1.06 (1.10,1.04)
Postgraduate degree	39450	-	-	-	39450	-	-	-
Member of household receives benefit income								
No	159069	-	-	-	158679	-	-	-
Yes	51777	0.57 (0.59,0.55)	0.65 (0.66,0.63)	0.66 (0.67,0.65)	51720	0.56 (0.58,0.55)	0.64 (0.66,0.63)	0.66 (0.67,0.65)
Family circumstances								

Age of mother at child's birth								
<20	14313	0.48 (0.51,0.46)	0.56 (0.59,0.54)	0.64 (0.66,0.62)	14313	0.48 (0.51,0.46)	0.56 (0.59,0.54)	0.64 (0.66,0.62)
20-24	41889	0.63 (0.66,0.61)	0.69 (0.72,0.67)	0.75 (0.77,0.74)	41889	0.63 (0.66,0.61)	0.69 (0.72,0.67)	0.75 (0.77,0.74)
25-29	55800	0.83 (0.86,0.79)	0.88 (0.90,0.85)	0.88 (0.91,0.87)	55800	0.83 (0.86,0.79)	0.88 (0.90,0.85)	0.88 (0.91,0.87)
30-34	66297	-	-	-	66297	-	-	-
35+	58977	0.90 (0.93,0.87)	0.89 (0.92,0.86)	0.95 (0.97,0.93)	58974	0.90 (0.93,0.87)	0.89 (0.92,0.86)	0.95 (0.97,0.93)
Father on birth certificate								
No	12612	0.56 (0.59,0.53)	0.61 (0.64,0.59)	0.60 (0.62,0.57)	12612	0.56 (0.59,0.53)	0.61 (0.64,0.59)	0.60 (0.62,0.57)
Yes	224664	-	-	-	224664	-	-	-
Mother speaks English								
No	3483	0.81 (0.90,0.72)	1.00 (1.10,0.92)	0.56 (0.60,0.53)	3483	0.81 (0.90,0.72)	1.00 (1.10,0.92)	0.56 (0.60,0.53)
Yes	196248	-	-	-	196248	-	-	-
Housing								
Urban	224976	-	-	-	215775	-	-	-
Rural	36630	1.05 (1.09,1.01)	1.03 (1.06,1.00)	1.59 (1.61,1.54)	35838	0.93 (0.96,0.89)	0.95 (0.98,0.93)	1.54 (1.59,1.52)
Household size								
2-4 people	121098	-	-	-	120852	-	-	-
5-7 people	77961	0.74 (0.76,0.71)	0.75 (0.76,0.72)	0.76 (0.77,0.75)	77808	0.74 (0.76,0.71)	0.74 (0.76,0.72)	0.76 (0.77,0.75)
8+ people	11784	0.42 (0.44,0.40)	0.51 (0.53,0.49)	0.36 (0.37,0.34)	11742	0.42 (0.44,0.40)	0.51 (0.53,0.49)	0.36 (0.37,0.34)

Own home	112581	-	-	-	112458	-	-	-
Rented home	94146	0.56 (0.57,0.54)	0.63 (0.65,0.62)	0.71 (0.72,0.69)	93840	0.56 (0.58,0.54)	0.64 (0.65,0.63)	0.71 (0.72,0.70)
Number of residence changes age 0-4								
None	61761	-	-	-	62412	-	-	-
1	57459	2.86 (2.94,2.78)	2.13 (2.17,2.08)	1.33 (1.37,1.30)	47994	1.16 (1.22,1.12)	1.01 (1.04,0.98)	0.90 (0.92,0.88)
2	42891	2.86 (2.94,2.70)	2.00 (2.08,1.92)	1.25 (1.28,1.22)	31935	0.96 (1.00,0.92)	0.85 (0.88,0.81)	0.83 (0.85,0.81)
3	28653	2.33 (2.44,2.22)	1.67 (1.72,1.61)	1.15 (1.18,1.11)	20745	0.85 (0.90,0.81)	0.73 (0.76,0.70)	0.78 (0.81,0.76)
4	18810	2.04 (2.13,1.92)	1.41 (1.47,1.37)	1.08 (1.11,1.04)	32235	0.66 (0.68,0.63)	0.60 (0.62,0.58)	0.76 (0.79,0.75)
5+	30447	1.56 (1.61,1.49)	1.16 (1.20,1.12)	1.05 (1.09,1.03)	62412	1.37 (1.43,1.32)	1.18 (1.22,1.14)	0.99 (1.01,0.97)
Health status								
Mother smoking status								
Regular smoker	38457	0.56 (0.57,0.53)	0.63 (0.65,0.61)	0.78 (0.79,0.76)	38460	0.56 (0.57,0.53)	0.63 (0.65,0.61)	0.78 (0.79,0.76)
Ex smoker	45420	0.94 (0.98,0.90)	0.90 (0.93,0.88)	1.08 (1.10,1.05)	45420	0.94 (0.98,0.90)	0.90 (0.93,0.88)	1.08 (1.10,1.05)
Never smoked	111219	-	-	-	111219	-	-	-
Birthweight								
<2500g	14049	0.57 (0.60,0.55)	0.73 (0.76,0.70)	0.87 (0.90,0.84)	14049	0.57 (0.60,0.55)	0.73 (0.76,0.70)	0.87 (0.90,0.84)
2500-4000g	187242	-	-	-	187239	-	-	-
>4000g	34746	1.01 (1.05,0.97)	0.96 (0.99,0.93)	1.04 (1.06,1.01)	34749	1.01 (1.05,0.97)	0.96 (0.99,0.93)	1.04 (1.06,1.01)

Gestation								
<37 weeks	17922	0.60 (0.63,0.57)	0.76 (0.79,0.73)	0.88 (0.91,0.85)	17922	0.60 (0.63,0.57)	0.76 (0.79,0.73)	0.88 (0.91,0.85)
37-42 weeks	217128	-	-	-	217128	-	-	-
>42 weeks	1443	1.00 (1.19,0.85)	0.97 (1.11,0.84)	0.67 (0.75,0.61)	1443	1.00 (1.19,0.85)	0.97 (1.11,0.84)	0.67 (0.75,0.61)
Child referred for disability support assessment								
No	261408	-	-	-	247875	-	-	-
Yes	4473	0.46 (0.50,0.43)	0.46 (0.49,0.43)	0.61 (0.65,0.57)	4401	0.34 (0.37,0.32)	0.38 (0.40,0.36)	0.56 (0.60,0.53)
Number of quarters enrolled with GP age 0-4								
0-3	25407	0.16 (0.17,0.16)	0.23 (0.24,0.22)	0.41 (0.42,0.39)	16215	0.16 (0.17,0.16)	0.20 (0.21,0.19)	0.42 (0.44,0.41)
4-7	41286	0.74 (0.77,0.72)	0.81 (0.83,0.78)	0.91 (0.93,0.89)	42645	0.53 (0.55,0.51)	0.54 (0.55,0.52)	0.83 (0.85,0.81)
8-11	90621	0.95 (0.98,0.92)	0.97 (1.00,0.94)	0.99 (1.01,0.97)	95298	0.76 (0.79,0.74)	0.78 (0.80,0.76)	0.98 (1.00,1.00)
12+	93174	-	-	-		-	-	-
Number of hospital admissions age 0-4								
None	104382	-	-	-	108081	-	-	-
1 to 2	104280	2.17 (2.22,2.13)	1.75 (1.82,1.72)	1.35 (1.37,1.32)	111288	1.32 (1.35,1.28)	1.23 (1.27,1.20)	1.14 (1.16,1.12)
3 to 5	21528	1.85 (1.92,1.79)	1.64 (1.72,1.59)	1.32 (1.35,1.27)	22668	1.06 (1.11,1.01)	1.11 (1.15,1.06)	1.09 (1.11,1.05)
6+	9834	1.23 (1.32,1.18)	1.19 (1.25,1.14)	1.12 (1.16,1.08)	10242	0.73 (0.77,0.69)	0.82 (0.86,0.78)	0.94 (0.98,0.91)

Total days in hospital age 0-4								
None	134751	-	-	-	141108	-	-	-
1 to 9	96537	1.92 (1.96,1.85)	1.59 (1.61,1.54)	1.27 (1.30,1.25)	102060	1.23 (1.27,1.20)	1.16 (1.19,1.14)	1.11 (1.12,1.09)
10 to 19	5022	1.28 (1.41,1.19)	1.22 (1.32,1.14)	0.98 (1.03,0.93)	5268	0.83 (0.91,0.77)	0.90 (0.96,0.84)	0.85 (0.90,0.81)
20+	3714	0.81 (0.88,0.75)	0.84 (0.91,0.78)	0.82 (0.88,0.77)	3843	0.53 (0.58,0.49)	0.63 (0.67,0.58)	0.72 (0.77,0.68)
Total number of ED visits age 0-4								
None	205911	-	-	-	215601	-	-	-
1 to 2	31854	1.20 (1.37,1.06)	0.96 (1.06,0.87)	0.63 (0.69,0.58)	34218	0.99 (1.02,0.95)	0.93 (0.95,0.90)	0.69 (0.71,0.68)
3+	2262	0.98 (1.01,0.96)	0.98 (1.00,0.96)	0.99 (1.01,0.98)	2457	0.85 (0.95,0.75)	0.76 (0.85,0.69)	0.58 (0.63,0.54)

Appendix 2

Percentage of children completing each component of B4SC, by year

	% of children completing check			
B4 School check	2011/12	2012/13	2013/14	2014/15
Vision	86.8	88.7	90.7	91.8
Hearing	86.8	88.6	90.6	91.8
Dental	79.4	82.1	86.7	88.4
Growth	79.4	82.1	86.7	88.4
Immunisation	79.1	81.9	86.3	87.9
PEDS	79.4	82.1	86.6	88.4
SDQP	79.3	81.9	86.5	88.2
SDQT	52.9	56.5	59.8	61.4

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1 (title)
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5,6
Objectives	3	State specific objectives, including any prespecified hypotheses	8
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	9-11
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	10-11
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	11-15
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	11-15
Bias	9	Describe any efforts to address potential sources of bias	*11, APPENDIX 2*
Study size	10	Explain how the study size was arrived at	11
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11-15
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	15-16
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	11, APPENDIX 2
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11
		(b) Give reasons for non-participation at each stage	11
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12-14, Tables 2 and 3
		(b) Indicate number of participants with missing data for each variable of interest	Tables 2 and 3
Outcome data	15*	Report numbers of outcome events or summary measures	Tables 2 and 3
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Tables 2 and 3
		(*b*) Report category boundaries when continuous variables were categorized	11-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	APPENDIX 2
Discussion			
Key results	18	Summarise key results with reference to study objectives	19
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	19-20
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	20-21
Generalisability	21	Discuss the generalisability (external validity) of the study results	19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	23

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

How Universal are Universal Pre-School Health Checks? An observational study using routine data from New Zealand's B4 School Check

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-025535.R2
Article Type:	Research
Date Submitted by the Author:	27-Feb-2019
Complete List of Authors:	Gibb, Sheree; University of Otago Wellington, Public Health; A Better Start National Science Challenge Milne, Barry; University of Auckland, Centre of Methods and Policy Application in the Social Sciences; University of Auckland Shackleton, Nichola; University of Auckland, Centre of Methods and Policy Application in the Social Sciences; A Better Start National Science Challenge Taylor, Barry; University of Otago, Department of the Dean; A Better Start National Science Challenge Audas, Richard; University of Otago Department of Women's and Children's Health; A Better Start National Science Challenge
Primary Subject Heading:	Public health
Secondary Subject Heading:	Health services research
Keywords:	healthcare disparities, data linkage, childhood intervention

How Universal are Universal Pre-School Health Checks? An observational study using routine data from New Zealand's B4 School Check

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Key words: healthcare disparities; data linkage; childhood intervention

Word count: 4383

Funding: This study was funded by A Better Start – National Science Challenge, New Zealand Ministry for Business, Innovation and Employment.

Disclaimer: Access to the data used in this study was provided by Statistics New Zealand under conditions designed to give effect to the security and confidentiality provisions of the Statistics Act 1975. The results presented in this study are the work of the authors, not Statistics NZ.

Abstract

Objectives: We aimed to estimate how many children were attending a universal pre-school health screen and to identify characteristics associated with non-participation.

Design: Analysis of population level linked administrative data.

Participants: Children were counted in the population of resident 4-year-olds for a given year if 1) they were ever resident in New Zealand, and 2) lived in NZ for at least 6 months during the reference year, 3) were alive at the end of the reference year, and either 4) appeared in any hospital (including emergency) admissions, community pharmaceutical dispensing, or GP enrolment datasets during the reference year, or 5) had a registered birth in New Zealand. We analysed 252,273 records over 4 years, from July 1st 2011 to June 30th 2015.

Results: We found that participation rates varied for each component of the B4 School Check (in 2014/15 91.8% for Vision and Hearing tests (VHT), 87.2% for nurse checks (including height, weight, oral health, SDQ, PEDS) and 62.1% for Teacher SDQ (SDQT)), but participation rates for all components increased over time. Māori and Pacific children were less likely to complete the checks than non-Māori and non-Pacific children (for VHT tests Māori OR=0.60 (0.61,0.58), Pacific OR=0.58 (0.60,0.56), for nurse checks Māori OR=0.63 (0.64,0.61), Pacific OR=0.67 (0.69,0.65), for SDQT Māori OR=0.76 (0.78,0.75), Pacific OR=0.37 (0.38,0.36)). Children from socioeconomically deprived areas, with younger mothers, from rented homes, residing in larger households, with worse health status, and with higher rates of residential mobility were less likely to participate in the B4 School Check than other children.

Conclusion: The patterns of non-participation suggest a reinforcing of existing disparities, whereby the children most in need are not getting the services they potentially require. There

needs to be an increased effort by public health organizations, community and whānau/family to ensure that all children are tested and screened.

Strengths and limitations of this study

- Whole population sample of all children completing B4 School check over 4 years (N=252,273)
- Using linked data from different sectors provided information about a wide range of characteristics
- Only bivariate analyses were possible; sample loss due to missing data meant that multivariate analysis was not feasible

Introduction

Globally, a common practice in childhood development is to screen children to determine if there are any key developmental problems that need to be assessed (1). These screens typically check for problems relating to general health, including hearing, vision, height, weight and oral health. They also often screen for emotional, behavioural, or intellectual issues that might be evident (2). Hall and Stewart-Brown categorize four types of screening programmes: i) biochemical; ii) screening involving objective measures (such as height and weight, vision and hearing; iii) screening involving physical examination; and iv) screening involving understanding of child development (3).

In New Zealand, the screen is called the Before School Check (B4SC) and it is administered to four year olds. It is the final and most comprehensive in a series of eight free Well Child Tamariki Ora visits that children receive (4), and currently the only one for which comprehensive linked data are available to examine coverage. The B4SC was implemented in New Zealand starting in September 2008, although it was not universal until 2010. There are eight key developmental areas that are assessed: vision, hearing, oral health, general health, growth measurement, strengths and difficulties (SDQ) as reported by parents and teachers and a parental evaluation of development status (PEDS). If concerns are identified in any area, children are referred for further testing or intervention. The B4SC is administered by the Ministry of Health, which has set a target 90% participation rate across the country, with parents and guardians being notified of the B4SC via enrolment with a primary health organisation (PHO, organisations that provide primary care services (5)). The Ministry's data

suggests they have been meeting their target since 2013, but compliance falls short of 100% (6). Furthermore, not all children are registered with a PHO (95% of 0-4 year olds are registered (7)), and including unregistered children in the denominator will further reduce compliance rates.

This raises three concerns: First, that a non-trivial number of children are missing their checks. Second, that some children may not be registered with a PHO and as such, their parents are not notified that their child should attend a B4SC. And third, that these children may be more likely to be in higher risk categories for later health problems and could benefit from the referrals to interventions that accompany this screen. It is this final concern that is the focus of this study.

Evidence Preschool / School Entry Screening Participation

Across different universal health checks available to the adult populations of different countries certain patterns persist: those in poorer socioeconomic circumstances, with lower qualifications, and at greater risk of health problems are less likely to attend such checks (8-13).

The available evidence for universal health checks in childhood suggests a similar pattern (14-16). Wood et al considered the coverage of universal child health reviews in Scotland (15). They considered two cohorts of children, the first, born in 1998/99 were eligible for 5 health checks (10 days/6-8 weeks/8-9 months/22-24 months and 39-42 months) and a second cohort, born in 2007/08, were only eligible for the first two checks. They found that coverage rates of

the 10-day check were very high in both cohorts (99%), but this declined as the children aged. For the 6-8 week review, coverage was between 94-95%, and for the 39-42 month review the coverage rates fell to 86%. There were clear deprivation gradients, with children living in the least deprived areas much more likely to have a health check than those in the most deprived areas, and these gradients increased substantially with increasing age and decreasing coverage. They conducted an audit on a subset of the areas included in the review (Glasgow and Fife). Consistent with the inverse care law (17) they found that children who missed the 6-8 week review were more likely to require additional health services and support in the future than those who attended the review.

Similarly, evidence from Denmark suggests that participation declines with age. Only 76% of eligible children attend the age 4 health screen. Child, parent and household level characteristics predicted attendance with children who had been hospitalised at least twice since birth, children of single, younger, less educated or immigrant parents, and children residing in low income households or living in institutions less likely to participate (16). Similarly in North Carolina children of mothers who were younger, less educated, black, and unmarried were also less likely to receive an adequate number of well child visits (14).

The overall aim of these universal checks is to identify children who are at risk of later problems and direct them towards interventions that will reduce this risk. The early identification of health and developmental issues increases the efficacy and cost effectiveness of treatment and lessens the risk of any potential comorbidities. However, evidence about whether or not childhood screening achieves this aim is mixed (18-20). Childhood screening relies on accurate

identification of children at risk, and also on the availability of effective interventions or treatments for at-risk children, which are not always available (19, 21). Regardless, universal checks are often the only instrument to identify children in need of additional services, who may otherwise be missed by the health system. Therefore, systematic differences in attendance highlight a crucial issue: those children most in need are missing out on vital services.

In New Zealand we are in a unique position to examine the characteristics of those not completing the B4SC. Many routinely collected government databases (including B4SC) are held in the Statistics New Zealand Integrated Data Infrastructure (IDI) and each individual is assigned a unique identifier which allows their records to be linked across data files. In this analysis we build a population cohort using birth records and immigration/emigration files to determine which four year-olds were in the country and eligible for the B4SC between July 1st 2011 to June 30th 2015, and then we examine the characteristics of those who do not get the B4SC.

The aim of this paper is to identify characteristics associated with non-participation in the B4SC by linking to deprivation, birth, census, health, disability and immunisation records, all of which are available in the IDI.

Methods

Study design

This study was an observational study using routine data from New Zealand's Integrated Data Infrastructure.

Data sources and linkage

All data were sourced from the Integrated Data Structure (22), a secure database containing anonymised microdata about individuals.

B4 School Check

The main outcome measures for this study were generates from B4 School Check data. The B4 School Check (B4SC) is a universal programme offered to all families in New Zealand with four-year-old children (23). If a child is enrolled with a primary health organisation a letter or email will be sent to parents inviting them to bring the child along for a B4SC. Parents can also request a check by approaching a general practitioner or other B4SC provider. The checks are carried out by registered nurses or nurse practitioners with experience in child health, with assistance from vision and hearing technicians (4). One component (SDQ-Teacher) is completed by a child's early childhood education (ECE) teacher, who receives the SDQ directly from the B4SC provider and is responsible for returning it to the provider (24). ECE coverage is high in New Zealand with more than 95% of children enrolled in ECE in the 6 months prior to starting school (25). The B4SC is undertaken in different locations including preschools, kōhanga reo (Māori language immersion early childhood education centres), doctors' clinics and other community venues such as churches and marae (meeting grounds and focal points for Māori

communities), depending on the needs of the community. In some cases, parts of the B4 School Check are carried out in the child's home.

The percentage attending the B4SC was estimated as 79% in 2011/2012, 80% in 2012/2013, 91% in 2013/2014, 92% in 2014/15, and 92% in 2015-2016 (6). High coverage of vulnerable groups (Māori children and children from areas of high socioeconomic deprivation) is encouraged by linking a portion of District Health Board (DHB, see (26)) funding for B4SC to achieving a specified level of coverage for these groups. In the 2015/16 year the coverage for Māori children was 88% and for Pacific children it was 89% (27). For children from high deprivation areas the coverage was 93% (6). This paper uses data from B4 school checks completed between the fiscal years 2011/12 and 2014/15.

Other datasets

Datasets used to construct the other analysis variables for this study were: Census 2013; Ministry of Health PHO enrolment and hospital discharge datasets; source ranked ethnicity; address notification; SOCRATES; and birth registrations. More detail on the variables constructed from these datasets can be found in the 'other analysis variables' section below.

Study population

To identify the population of children eligible for a B4SC, annual populations of four-year-old children were constructed using methods developed previously for constructing populations from the Integrated Data Infrastructure (IDI) (28, 29). Children were included in the denominator population for a given year if they:

- Appeared in any hospital (including emergency) admissions, community pharmaceutical dispensing, or PHO enrolment datasets during the reference year; OR

- Had a NZ birth record.

The above population was then restricted to children who lived in NZ for at least 6 months during the reference year, were alive at the end of the reference year, were included in the IDI spine (which aims to cover an "ever-resident" population including all those who either were born in New Zealand, migrated to New Zealand, or paid tax in New Zealand (30)).

Over the four-year period we identified 288,753 children who had a health or birth record. Of those, 277,593 (96%) were in the IDI spine, and 252,273 of those (91%) were alive and resident in New Zealand at the end of their reference year and were used as the denominator population.

To examine whether the above criteria had an impact on study results we conducted a sensitivity analysis in which we replicated the analysis using two different definitions of the study population. The main conclusions of the study were the same across all replications. The detailed results of the sensitivity analysis can be found in Appendix 1.

Outcomes

B4SC completion

For the purposes of this study, B4SC was grouped into three components: Vision and Hearing Test (VHT) checks (vision and hearing); nurse checks (growth, dental, immunisation, Parents Evaluation of Developmental Status (PEDS), and Strengths and Difficulties Questionnaire (SDQ) Parent); and SDQ Teacher. These groupings were developed in consultation with the Ministry of

Health and reflect the way in which the components are typically completed (vision and hearing checks are usually completed together by vision and hearing technicians, the nurse checks are usually completed together, SDQ-Teacher is completed separately by a child's early childhood education teacher). In some regions these groups of checks are administered in separate visits; in other regions they are combined into a single visit. If a child had completed all checks within a component they were considered to have completed that component. B4SC coverage was calculated as the number of children completing a B4SC component divided by the total number of children in the population. Completion rates for the individual component checks can be found in Appendix 2.

Other analysis variables

Ethnicity

Ethnicity measures were taken from the source ranked ethnicity table in IDI. The table collates ethnicities that are reported to different administrative collections in IDI and ranks these sources to provide an ethnic profile for each individual. Ranking is based on how closely the ethnicities reported for an individual in the administrative source match those reported in the census (census records have highest priority and 84.3% of the study population had ethnicity sourced from census, followed by birth records (13.9%), followed by health (1.7%))(31). From this we constructed four dichotomous ethnicity variables representing whether or not children were recorded as identifying with each of the following major ethnic groups: Māori; Pacific; Asian; European. Individuals could belong to none, one, or more than one of these ethnic

groups. Identifying as more than one ethnicity is common in New Zealand (32) and 23.9% of the current sample belonged to multiple ethnic groups.

Socioeconomic deprivation

NZ Deprivation Score (NZDep) was calculated using the standard 2013 NZDep concordance (33) and the child's meshblock (small geographic area typically containing 30-80 dwellings (34)) of usual residence at the time of the 4th birthday, or the first meshblock recorded within 12 months after the date of the 4th birthday if no meshblock was recorded prior to that. Each meshblock was assigned a decile from 1 (least deprived) to 10 (most deprived). These were then grouped into quintiles.

Urbanicity

The child's meshblock of usual residence was also used to define urbanicity. The standard classification of urban/rural areas in New Zealand (35) is a five-point scale: 1) Main urban (centred on a city or major urban area, population of at least 30,000), 2) secondary urban (centred on larger regional centres, population 10,000-29,999), 3) minor urban (centred around smaller towns, population 1,000–9,999), 4) rural centre (population 300-999) and 5) other rural (population <300). These were collapsed into two groups: urban (main urban, secondary urban, and minor urban area) and rural (rural centre and other rural).

Residence changes

The total number of different addresses lived at from birth to fourth birthday (minus one to give the number of changes) was calculated from the address notification table in IDI which collates address updates reported to data providers.

Hospitalisations

The following variables were obtained from hospital records: total number of hospital admissions (excluding the child's birth and any emergency department visits that did not result in hospital admission) from birth to fourth birthday; the total number of days spent in hospital for those visits; total number of emergency department visits from birth to fourth birthday.

GP enrolment

The extent to which a child had continuous enrolment with a general practitioner was estimated by counting the number of quarters in which a child was enrolled with a Primary Health Organisation (umbrella organisations for general practitioners) from birth to fourth birthday.

Disability

Children who received a referral to Disability Support Services before their fourth birthday were classified as having a disability.

Information from birth record

Birth records were available for 94.1% of the total sample. The following variables were obtained from the child's birth record: the child's birth weight, in grams; gestational age, categorised into <37 weeks, 37-42 weeks, and >42 weeks; whether or not a father was recorded on the child's birth certificate; age of the child's mother at the time of the child's birth, grouped into under 20; 20-24; 25-29; 30-34; 35 and over.

Variables from census records

Additional variables were obtained by linking to census records. Household variables were obtained by linking to the household form connected to the child's census record, 82.9% of children had census household information available. Mother and father variables were obtained by first linking to the child's birth record to identify mother and father, and then linking to census records for the mother and father. 79.8% of children had mother census information available; 68.5% had father census information available. All census variables are recorded as at Census day (5 March 2013). The variables from Census were: size of household (including child), grouped into: 2 to 4 people; 5 to 7 people; 8 or more people; whether the dwelling was rented or owned (including those held in family trusts); whether or not any member of the child's household received benefit income in the year to 5 March 2013; whether or not the child's mother spoke enough English to have a conversation about everyday things; the highest qualification of the child's mother and father at the time of the 2013 census, classified into: no formal qualifications; high school qualifications; tertiary qualification below Bachelor degree; Bachelor degree or higher; the current smoking status of the child's mother at the time of the census, classified into: current regular smoker; ex-smoker; never smoked.

Analysis

All analyses were conducted using SAS Enterprise Guide version 9 within the secure data lab environment. First, we constructed the population, and calculated rates of those who completed components (VHT, nurse checks, SDQT) of the B4SC. Second, we compared the characteristics of those who did not complete a component compared to those who did by fitting logistic regression models in which B4SC completion was modelled as a function of the relevant predictor. Odds ratios and 95% confidence intervals were calculated from the logistic regression coefficients.

Patient and public involvement

Patients and public were not involved in the design or conduct of this study.

Results

Table 1 shows the total number of children in the denominator (eligible) population for each year, and the number and percentage of children who completed the VHT, nurse and SDQT components of the B4SC, by year. In all years, completion was highest for the VHT component and lowest for the SDQ Teacher component. Approximately 52% to 62% of children completed the SDQ Teacher component, compared to 78% to 87% for the nurse components and 86% to 91% for the VHT components. Coverage was lowest in 2011/12 and highest in 2014/15.

INSERT TABLE 1 HERE

Tables 2 and 3 show the associations between completion of each B4SC component for 2011/12 to 2014/15 (all years combined), and a range of characteristics. Sociodeomgraphic characteristics are reported in Table 1 and health and perinatal characteristics in Table 2. The tables show the number and percentage of children completing each B4SC component, the odds ratio and 95% confidence intervals.

Most of the sociodemographic characteristics presented in Table 1 were significantly associated with B4SC completion. Children were more likely to complete a check if they: were of European (compared to not European) or Asian (compared to not Asian) ethnicity; had fewer siblings; came from areas of lower socioeconomic deprivation; had a mother with a Bachelor degree; had mothers aged 30-34; lived in a home that was owned rather than rented; lived in a smaller (2-4 person) household; and lived in a household that does not receive benefit income.

The health and perinatal characteristics presented in Table 2 were all significantly associated with B4SC completion. Children were more likely to complete a B4SC if they: had a mother that had never smoked; weighed between 2500 and 4000 grams at birth; had a gestational age of between 37 and 42 weeks; were not referred for disability support; spent more time enrolled with a GP; had lower numbers of hospital and emergency department admissions and spent fewer days in hospital.

INSERT TABLE 2 HERE

Discussion

Our results demonstrate that Māori and Pacific children, those in poorer socioeconomic circumstances, and with poorer health are less likely to complete the B4SC. Children living in areas of higher socioeconomic deprivation, without a father named on the birth certificate, with mothers and fathers with lower levels of education, living in households with 5 or more people, having multiple changes in residence in the early years of life and living in rental accommodation have a lower likelihood of B4SC completion. Children with indicators of poor health outcomes including having a mother who smokes and having a low birth weight also have a lower likelihood of B4SC completion. Given that these factors tend to be associated with poorer child health outcomes (36, 37), our results paint a consistent pattern, demonstrating that across a wide range of measures of vulnerability, those children who would potentially most benefit from a B4SC screen and the referrals to interventions are less likely to participate.

A strength of this study is the large, linked dataset that was used (the Integrated Data Infrastructure, IDI). The IDI is a whole population data source and therefore it allows us to include children who are often excluded from other analyses, such as those not in regular contact with health services. Furthermore, the large number of data sources included in the IDI allows us to examine a wider range of characteristics than would be available in any single source.

While this study is novel, and provides vital information for service providers, all of the analyses presented in this paper are bivariate. It is likely that children who are disadvantaged in one area are also at a disadvantage in other areas (that is, the predictors of B4SC completion are correlated). Multivariate analysis would provide more detailed information about the joint or relative impact of different predictors on B4 School check completion. However, to run multivariate analysis we would have to restrict our sample to children born in NZ, with a mother

and father who completed 2013 census. These restrictions would reduce the sample to less than 70% of the total sample and would exclude all migrants, making the results difficult to generalise to the whole population. For this reason we have chosen not to undertake multivariate analysis in this paper.

Our findings are consistent with existing literature on the coverage of child health checks (14-16), and provide further support for the inverse care law – that those with the greatest need are the least likely to seek services (17). There is currently very little research in this area for child health screens, but the application of the inverse care law is a consistent finding among free health checks for the adult population (8-13). However, the reasons why people most in need do not attend are not well understood, and there is a need for qualitative research investigating why parents are not taking children to free health checks.

Several potential explanations for non-attendance at adult health checks have been put forward that may be applicable to child health checks including lack of awareness, time constraints and access issues (10), and misunderstanding the purpose/scepticism. Focus groups conducted with low income Māori and Pacific parents have identified concerns about relevance of the B4SC checks, children and parents being judged, and language and cultural understanding as potential barriers to participation (38). Lack of awareness of the checks was also identified as a problem, and this may be a particular issue for children who are not enrolled on the PHO system (5% of children) or who have incorrect address information and thus do not receive the invitation letter. Access could also be an issue with many of the B4 School checks being carried out by Plunket or other health services which are only open during normal office hours, and not at weekends (38, 39). Therefore, households where both parents work, or single-parent working households will not easily be able to attend. Furthermore, for less densely populated regions in New Zealand there are

fewer centres offering B4 School checks, compared to more densely populated regions such as Auckland, Wellington or Christchurch (39), meaning it is less convenient to attend. Scepticism about the value of attending and the purpose of the screens is likely to differ by ethnic group, as research persistently demonstrates that Māori receive a poorer quality and slower service, and are less likely to receive appropriate levels of care (40-42). There are similar findings for Pacific peoples also (43-45). Therefore these groups may be less trusting of the New Zealand health system (46).

Socioeconomic and ethnic inequalities in health-seeking and health outcomes within New Zealand are well documented for both the adult and child population (44, 45, 47). A long standing objective of the New Zealand government is to reduce health and socio-economic disparities, particularly for Māori and Pacific families. Patterns of participation at the B4SC could be reinforcing existing ethnic and socioeconomic disparities. Early intervention is one means of reducing inequities (48, 49). Although evidence for the effectiveness of childhood screening is mixed, at present it appears that any potential benefits that do result from the B4SC will be unevenly distributed across ethnic and socioeconomic groups. Improving B4SC participation would be a cost-effective path towards converging outcomes and would ensure that any benefits from the screen are reaching children who are most at risk of later health concerns.

Although 100% attendance in the B4SC is unlikely, we believe that a greater effort is required to reach the most vulnerable families to ensure that more children who would benefit from the B4SC will get access to the interventions that arise from it. This will require greater outreach and public awareness, but also examining whether access and cultural relevance of the B4SC could be improved. Interventions such as phone, letter or text message reminders have been shown to

increase the uptake of health checks and are one option that could be explored to increase B4SC uptake (50, 51).

An area where there has been some success in getting increased services to hard-to-reach populations has been through mobile programs and services (52, 53). For example, in America community health vans have shown success in reaching underserved populations such a low-income minority groups and immigrants for a range of health needs including earlier access to prenatal care and disease prevention screening (54-56). The Family Van run by Harvard Medical School offers a diverse range of health services, and has saved an estimated $2.8 million in avoided emergency room visits over the last 5 years with an estimated $23 saving per $1 spent (57). In addition, direct contact with those not participating should be considered with a greater push to ensure that those with characteristics of vulnerability are encouraged to attend. Further research is necessary on barriers to attendance identified and remedial action taken.

We have not followed children to determine whether missing a B4SC does in fact have an impact on later life outcomes, and this clearly needs to be assessed. We plan to address this question in future work, although the limited time series for the B4SC means that we will only be able to examine outcomes up to age 15.

Conclusion

Using a rich and diverse range of measures, we find that children with indicators of socioeconomic deprivation or poor health are less likely to participate in the B4SC and as such they may miss referrals for programs and interventions that may increase their readiness to enter school. We believe the patterns we observe in B4SC participation suggest a potential reinforcing of existing

inequalities and require increased effort to ensure that all children are tested and screened, and that those with the greatest need get access to health services, programmes and interventions.

Footnotes

Contributorship statement

RA, BM, BT and SG conceived the study. SG extracted data and did the main data analysis. NS provided statistical advice. All authors wrote and reviewed the manuscript, gave critical feedback and approved the final version for publication.

Competing interests

None.

Data sharing statement

Due to privacy regulations around the Integrated Data Infrastructure, data from this study are not available for sharing.

Ethical approval: This study was approved by the University of Otago Human Ethics Committee (ref D16/088).

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Table 1. Percentage of children completing B4SC components, by year

Fiscal year	N	N (%) VHT[a] complete	N (%) nurse[b] checks complete	N (%) SDQ[c] Teacher complete
2011/12	63,714	54,924 (86.2)	49,986 (78.5)	33,690 (52.9)
2012/13	62,664	55,344 (88.5)	50,814 (81.4)	35,433 (57.3)
2013/14	63,372	57,294 (90.5)	54,183 (85.6)	37,881 (60.0)
2014/15	62,529	57,282 (91.8)	54,348 (87.2)	38,379 (62.1)

[a] VHT = vision and hearing checks

[b] Nurse = dental, growth, immunisations, PEDS (Parent Evaluation of Developmental Status), SDQ-P (Strengths and difficulties questionnaire – Parent) check

[c] SDQ = Strengths and Difficulties Questionnaire

Table 2. Percentage of children completing B4SC, and odds ratios for completing, by sociodemographic, family and housing characteristics

	N (%)	N (%) complete			OR (95% CI)		
		VHT[a]	Nurse[b] checks	SDQ[c] Teacher	VHT	Nurse checks	SDQ Teacher
Sex							
Male	129,831 (51.5)	115,611 (89.0)	107,565 (82.9)	74,754 (57.6)	0.98 (1.01,0.96)	0.98 (1.00,0.96)	1.00 (1.01,0.98)
Female	122,439 (48.5)	109,227 (89.2)	101,766 (83.1)	70,629 (57.7)	-	-	-
missing	0 (0.0)						
Ethnicity							
Māori	71,196 (28.2)	60,714 (85.3)	55,491 (77.9)	37,575 (52.8)	0.60 (0.61,0.58)	0.63 (0.64,0.61)	0.76 (0.78,0.75)
Pacific	37,857 (15.0)	31,788 (84.0)	29,436 (77.8)	14,004 (37.0)	0.58 (0.60,0.56)	0.67 (0.69,0.65)	0.37 (0.38,0.36)
Asian	30,825 (12.2)	28,116 (91.2)	26,745 (86.8)	16,110 (52.3)	1.30 (1.35,1.25)	1.39 (1.45,1.35)	0.78 (0.80,0.76)
European	173,235 (68.7)	157,269 (90.8)	146,526 (84.6)	109,842 (63.4)	1.67 (1.72,1.64)	1.41 (1.45,1.39)	2.13 (2.17,2.08)
missing	0 (0.0)						
Number of siblings at time of birth							

0	123,123 (48.8)	110,223 (89.5)	103,509 (84.1)	71,829 (58.3)	-	-	-
1	70,626 (28.0)	64,260 (91.0)	59,877 (84.8)	42,615 (60.3)	1.18 (1.22,1.15)	1.05 (1.09,1.03)	1.09 (1.11,1.06)
2+	43,527 (17.3)	37,413 (86.0)	34,053 (78.2)	22,782 (52.3)	0.71 (0.74,0.69)	0.68 (0.70,0.66)	0.78 (0.80,0.77)
missing	15,003 (5.9)						
Socioeconomic deprivation							
NZDep quintile							
1 (least deprived)	50,520 (20.0)	46,584 (92.2)	43,530 (86.2)	32,199 (63.7)	-	-	-
2	46,323 (18.4)	42,150 (91.0)	39,282 (84.8)	28,182 (60.8)	0.85 (0.89,0.81)	0.89 (0.93,0.86)	0.88 (0.91,0.86)
3	45,672 (18.1)	41,145 (90.1)	38,199 (83.6)	27,810 (60.9)	0.77 (0.80,0.74)	0.82 (0.85,0.79)	0.88 (0.91,0.86)
4	47,043 (18.6)	41,736 (88.7)	38,895 (82.7)	27,423 (58.3)	0.66 (0.69,0.64)	0.77 (0.79,0.74)	0.79 (0.81,0.78)
5 (most deprived)	61,854 (24.5)	52,848 (85.4)	49,080 (79.3)	29,502 (47.7)	0.50 (0.52,0.48)	0.62 (0.64,0.60)	0.52 (0.53,0.51)
missing	867 (0.3)						
Mother's highest qualification							
No formal qualifications	27,672 (11.0)	24,012 (86.8)	22,452 (81.1)	15,213 (55.0)	0.48 (0.51,0.46)	0.61 (0.63,0.58)	0.68 (0.70,0.66)

Secondary school	67,047 (26.6)	60,861 (90.8)	57,180 (85.3)	40,173 (59.9)	0.72 (0.75,0.69)	0.82 (0.85,0.79)	0.83 (0.85,0.81)
Tertiary qualification below Bachelor degree	41,901 (16.6)	38,430 (91.7)	35,868 (85.6)	25,452 (60.7)	0.81 (0.85,0.78)	0.84 (0.87,0.81)	0.86 (0.88,0.84)
Bachelor degree or higher	57,570 (22.8)	53,631 (93.2)	50,442 (87.6)	36,972 (64.2)	-	-	-
missing	58,089 (23.0)						
Father highest qualification							
No formal qualification	26,712 (10.6)	23,784 (89.0)	22,251 (83.3)	15,549 (58.2)	0.65 (0.68,0.61)	0.73 (0.76,0.70)	0.82 (0.85,0.79)
Secondary school	51,177 (20.3)	46,866 (91.6)	44,094 (86.2)	30,960 (60.5)	0.86 (0.91,0.82)	0.91 (0.94,0.88)	0.90 (0.93,0.88)
Tertiary qualification below Bachelor degree	47,391 (18.8)	43,878 (92.6)	41,253 (87.0)	30,579 (64.5)	0.99 (1.04,0.94)	0.98 (1.02,0.94)	1.06 (1.10,1.04)
Bachelor degree or higher	39,447 (15.6)	36,546 (92.6)	34,413 (87.2)	24,840 (63.0)	-	-	-
missing	87,552 (34.7)						
Member of household receives benefit income							
No	158,679 (62.9)	147,216 (92.8)	138,420 (87.2)	100,071 (63.1)	-	-	-
Yes	51,720 (20.5)	45,438 (87.9)	42,093 (81.4)	27,339 (52.9)	0.56 (0.58,0.55)	0.64 (0.66,0.63)	0.66 (0.67,0.65)

missing	41,880 (16.6)						
Family circumstances							
Age of mother at child's birth							
<20	14,310 (5.7)	11,910 (83.2)	10,983 (76.8)	7,104 (49.6)	0.48 (0.51,0.46)	0.56 (0.59,0.54)	0.64 (0.66,0.62)
20-24	41,889 (16.6)	36,333 (86.7)	33,624 (80.3)	22,518 (53.8)	0.63 (0.66,0.61)	0.69 (0.72,0.67)	0.75 (0.77,0.74)
25-29	55,800 (22.1)	49,950 (89.5)	46,698 (83.7)	32,247 (57.8)	0.83 (0.86,0.79)	0.88 (0.90,0.85)	0.88 (0.91,0.87)
30-34	66,297 (26.3)	60,441 (91.2)	56,631 (85.4)	40,233 (60.7)	-	-	-
35+	58,977 (23.4)	53,259 (90.3)	49,500 (83.9)	35,121 (59.6)	0.90 (0.93,0.87)	0.89 (0.92,0.86)	0.95 (0.97,0.93)
missing	15,006 (5.9)						
Father on birth certificate							
No	196,248 (77.8)	10,467 (83.0)	9,567 (75.9)	5,763 (45.7)	0.56 (0.59,0.53)	0.61 (0.64,0.59)	0.60 (0.62,0.57)
Yes	3,483 (1.4)	201,429 (89.7)	187,872 (83.6)	131,463 (58.5)	-	-	-
missing	52,548 (20.8)						

Mother speaks English							
No	3,483 (1.4)	3,102 (89.1)	2,973 (85.4)	1,617 (46.4)	0.81 (0.90,0.72)	1.00 (1.10,0.92)	0.56 (0.60,0.53)
Yes	196,248 (77.8)	178,578 (91.0)	167,448 (85.3)	119,013 (60.6)	-	-	-
missing	52,548 (20.8)						
Housing							
Urban	35,838 (14.2)	31,767 (88.6)	29,565 (82.5)	23,832 (66.5)	-	-	-
Rural	215,775 (85.5)	192,864 (89.4)	179,577 (83.2)	121,410 (56.3)	0.93 (0.96,0.89)	0.95 (0.98,0.93)	1.54 (1.59,1.52)
missing	666 (0.3)						
Household size							
2-4 people	120,849 (47.9)	112,266 (92.9)	105,930 (87.7)	77,817 (64.4)	-	-	-
5-7 people	77,808 (30.8)	70,464 (90.6)	65,388 (84.0)	44,976 (57.8)	0.74 (0.76,0.71)	0.74 (0.76,0.72)	0.76 (0.77,0.75)
8+ people	11,739 (4.7)	9,921 (84.5)	9,195 (78.3)	4,617 (39.3)	0.42 (0.44,0.40)	0.51 (0.53,0.49)	0.36 (0.37,0.34)
missing	41,883 (16.6)						

Own home	112,458 (44.6)	105,333 (93.7)	99,384 (88.4)	72,561 (64.5)	-	-	-
Rented home	93,840 (37.2)	83,745 (89.2)	77,823 (82.9)	52,911 (56.4)	0.56 (0.58,0.54)	0.64 (0.65,0.63)	0.71 (0.72,0.70)
missing	45,981 (18.2)						
Number of residence changes age 0-4							
None	52,602 (20.9)	47,184 (89.7)	44,745 (85.1)	32,124 (61.1)	-	-	-
1	55,359 (21.9)	51,327 (92.7)	48,315 (87.3)	33,813 (61.1)	1.47 (1.52,1.41)	1.20 (1.25,1.16)	1.00 (1.02,0.98)
2	42,087 (16.7)	38,481 (91.4)	35,949 (85.4)	24,696 (58.7)	1.22 (1.28,1.18)	1.03 (1.06,0.99)	0.90 (0.93,0.88)
3	28,320 (11.2)	25,299 (89.3)	23,397 (82.6)	15,963 (56.4)	0.96 (1.01,0.92)	0.83 (0.87,0.80)	0.83 (0.85,0.80)
4	18,675 (7.4)	16,407 (87.9)	14,937 (80.0)	10,236 (54.8)	0.83 (0.88,0.79)	0.70 (0.73,0.67)	0.78 (0.80,0.75)
5+	30,282 (12.0)	25,599 (84.5)	23,181 (76.6)	16,419 (54.2)	0.63 (0.65,0.60)	0.57 (0.60,0.55)	0.76 (0.78,0.74)
missing	24,957 (9.9)						

Note: As individuals can identify as multiple ethnicities, counts for ethnic groups will sum to greater than the count for the total population. The reference groups for ethnicities are people not identifying with that ethnic group (for example, Māori is compared to non-Māori).

[a] VHT = vision and hearing checks

[b] Nurse = dental, growth, immunisations, PEDS (Parent Evaluation of Developmental Status), SDQ-P (Strengths and difficulties questionnaire – Parent)

check

[c] SDQ = Strengths and Difficulties Questionnaire

Table 3. Percentage of children completing B4SC, and odds ratios for completing, by perinatal and health characteristics

		% complete			OR (95% CI)		
	N	VHT[a]	Nurse[b] checks	SDQ[c] Teacher	VHT	Nurse checks	SDQ Teacher
Mother smoking status							
Regular smoker	38,460 (15.2)	33,366 (86.8)	31,026 (80.7)	21,240 (55.2)	0.56 (0.57,0.53)	0.63 (0.65,0.61)	0.78 (0.79,0.76)
Ex smoker	45,420 (18.0)	41,670 (91.7)	38,925 (85.7)	28,647 (63.1)	0.94 (0.98,0.90)	0.90 (0.93,0.88)	1.08 (1.10,1.05)
Never smoked	111,219 (44.1)	102,540 (92.2)	96,642 (86.9)	68,214 (61.3)	-	-	-
missing	57,180 (22.7)						
Birthweight							
<2500g	14,049 (5.6)	11,751 (83.6)	11,112 (79.1)	7,680 (54.7)	0.57 (0.60,0.55)	0.73 (0.76,0.70)	0.87 (0.90,0.84)
2500-4000g	187,239 (74.2)	168,387 (89.9)	156,939 (83.8)	108,762 (58.1)	-	-	-
>4000g	34,746 (13.8)	31,287 (90.0)	28,947 (83.3)	20,496 (59.0)	1.01 (1.05,0.97)	0.96 (0.99,0.93)	1.04 (1.06,1.01)
missing	16,245 (6.4)						
Gestation							

<37 weeks	17,925 (7.1)	15,105 (84.3)	14,256 (79.5)	9,888 (55.2)	0.60 (0.63,0.57)	0.76 (0.79,0.73)	0.88 (0.91,0.85)
37-42 weeks	217,128 (86.1)	195,228 (89.9)	181,734 (83.7)	126,483 (58.3)	-	-	-
>42 weeks	1,443 (0.6)	1,299 (90.0)	1,200 (83.2)	0,696 (48.2)	1.00 (1.19,0.85)	0.97 (1.11,0.84)	0.67 (0.75,0.61)
missing	15,783 (6.3)						
Child referred for disability support assessment							
No	247,878 (98.3)	221,568 (89.4)	206,451 (83.3)	143,463 (57.9)	-	-	-
Yes	4,401 (1.7)	3,270 (74.3)	2,880 (65.4)	1,917 (43.6)	0.34 (0.37,0.32)	0.38 (0.40,0.36)	0.56 (0.60,0.53)
missing	0 (0.0)						
Number of quarters enrolled with GP age 0-4							
0-3	9,438 (3.7)	5,328 (56.5)	4,464 (47.3)	2,826 (29.9)	0.10 (0.11,0.10)	0.13 (0.13,0.12)	0.29 (0.30,0.27)
4-7	37,671 (14.9)	32,592 (86.5)	29,547 (78.4)	20,919 (55.5)	0.52 (0.54,0.50)	0.52 (0.54,0.51)	0.83 (0.85,0.81)
8-11	92,856 (36.8)	83,955 (90.4)	78,396 (84.4)	55,284 (59.5)	0.76 (0.79,0.74)	0.78 (0.80,0.76)	0.98 (1.00,0.96)

12+	97,800 (38.8)	90,510 (92.5)	85,527 (87.5)	58,638 (60.0)	-	-	-
missing	14,505 (5.7)						
Number of hospital admissions age 0-4							
None	93,474 (37.1)	83,109 (88.9)	77,238 (82.6)	53,415 (57.1)	-	-	-
1 to 2	102,696 (40.7)	93,810 (91.3)	87,636 (85.3)	61,803 (60.2)	1.32 (1.35,1.28)	1.22 (1.25,1.19)	1.14 (1.15,1.11)
3 to 5	21,390 (8.5)	19,101 (89.3)	17,937 (83.9)	12,633 (59.1)	1.04 (1.09,0.99)	1.09 (1.14,1.05)	1.09 (1.11,1.05)
6+	9,762 (3.9)	8,277 (84.8)	7,707 (78.9)	5,397 (55.3)	0.69 (0.74,0.65)	0.79 (0.83,0.75)	0.93 (0.97,0.89)
missing	24,957 (9.9)						
Total days in hospital age 0-4							
None	123,231 (48.8)	110,022 (89.3)	102,492 (83.2)	71,280 (57.8)	-	-	-
1 to 9	95,478 (37.8)	86,991 (91.1)	81,243 (85.1)	57,501 (60.2)	1.23 (1.27,1.19)	1.15 (1.18,1.12)	1.10 (1.12,1.09)
10 to 19	4,953 (2.0)	4,323 (87.3)	4,041 (81.6)	2,664 (53.8)	0.83 (0.90,0.76)	0.90 (0.96,0.83)	0.85 (0.90,0.80)
20+	3,660 (1.5)	2,961 (80.9)	2,742 (74.9)	1,809 (49.4)	0.51 (0.55,0.47)	0.61 (0.65,0.56)	0.71 (0.76,0.67)

missing	24,957 (9.9)						
Total number of ED visits age 0-4							
None	193,905 (76.9)	174,354 (89.9)	162,942 (84.0)	116,460 (60.1)	-	-	-
1 to 2	31,173 (12.4)	27,960 (89.7)	25,791 (82.7)	15,759 (50.6)	0.97 (1.01,0.93)	0.91 (0.94,0.88)	0.68 (0.69,0.66)
3+	2,244 (0.9)	1,980 (88.2)	1,788 (79.7)	1,032 (46.0)	0.84 (0.96,0.74)	0.75 (0.83,0.68)	0.56 (0.61,0.52)
missing	24,957 (9.9)						

Note: As individuals can identify as multiple ethnicities, counts for ethnic groups will sum to greater than the count for the total population. The reference groups for ethnicities are people not identifying with that ethnic group (for example, Māori is compared to non-Māori).

[a] VHT = vision and hearing checks

[b] Nurse = dental, growth, immunisations, PEDS (Parent Evaluation of Developmental Status), SDQ-P (Strengths and difficulties questionnaire – Parent)

check

[c] SDQ = Strengths and Difficulties Questionnaire

Appendix 1

Sensitivity analysis

The table below shows the effects of:

1. Changing the criteria for inclusion in the population (column 1). In the main analyses, children were included in the population if they were in the IDI spine AND had health or birth records. Column 1 of the table below shows the results when the population was defined as children who were in the IDI spine OR had birth or health records.

2. Changing the overseas time cut-off for exclusion from the residential mobility and hospitalisation analyses (column 2, differences only apply to hospitalisation and meshblock change variables). In the main analyses, children were excluded if they had spent more than a year overseas. Column 2 of the table below shows the results if all children were included regardless of the amount of time spent overseas.

	Different population				Different overseas cut-off			
		OR (95% CI)				OR (95% CI)		
	N	VHT incomplete	Nurse checks incomplete	SDQ Teacher incomplete	N	VHT incomplete	Nurse checks incomplete	SDQ Teacher incomplete
Sex								
Male	136896	0.98 (1.01,0.96)	0.98 (1.00,0.96)	0.99 (1.01,0.98)	129834	0.98 (1.01,0.96)	0.98 (1.00,0.96)	1.00 (1.01,0.98)
Female	128967	-	-	-	122439	-	-	-
Ethnicity								
Māori	73092	0.76 (0.79,0.75)	0.74 (0.75,0.72)	0.81 (0.82,0.79)	71196	0.60 (0.61,0.58)	0.63 (0.64,0.61)	0.76 (0.78,0.75)
Pacific	39903	0.60 (0.62,0.59)	0.68 (0.69,0.66)	0.38 (0.39,0.37)	37857	0.58 (0.60,0.56)	0.67 (0.69,0.65)	0.37 (0.38,0.36)
Asian	33039	1.09 (1.12,1.04)	1.20 (1.23,1.16)	0.76 (0.78,0.75)	30825	1.30 (1.35,1.25)	1.39 (1.45,1.35)	0.78 (0.80,0.76)
European	180345	1.72 (1.75,1.69)	1.49 (1.52,1.47)	2.13 (2.17,2.13)	173232	1.67 (1.72,1.64)	1.41 (1.45,1.39)	2.13 (2.17,2.08)
	136896	0.98 (1.01,0.96)	0.98 (1.00,0.96)	0.99 (1.01,0.98)	129834	0.98 (1.01,0.96)	0.98 (1.00,0.96)	1.00 (1.01,0.98)
Number of siblings at time of birth								
0	123123	-	-	-	123126	-	-	-
1	70626	1.18 (1.22,1.15)	1.05 (1.09,1.03)	1.09 (1.11,1.06)	70629	1.18 (1.22,1.15)	1.05 (1.09,1.03)	1.09 (1.11,1.06)
2+	43527	0.71 (0.74,0.69)	0.68 (0.70,0.66)	0.78 (0.80,0.77)	43527	0.71 (0.74,0.69)	0.68 (0.70,0.66)	0.78 (0.80,0.77)
Socioeconomic deprivation								
NZDep quintile								
1 (least deprived)	52995	-	-	-	50517			
2	48081	0.89 (0.93,0.86)	0.92 (0.95,0.88)	0.89 (0.92,0.87)	46326	0.85 (0.89,0.81)	0.89 (0.93,0.86)	0.88 (0.91,0.86)

3	47283	0.82 (0.85,0.79)	0.85 (0.88,0.82)	0.89 (0.92,0.88)	45672	0.77 (0.80,0.74)	0.82 (0.85,0.79)	0.88 (0.91,0.86)
4	48720	0.72 (0.75,0.69)	0.79 (0.82,0.77)	0.81 (0.83,0.79)	47043	0.66 (0.69,0.64)	0.77 (0.79,0.74)	0.79 (0.81,0.78)
5 (most deprived)	64308	0.54 (0.56,0.53)	0.64 (0.66,0.62)	0.53 (0.54,0.52)	61854	0.50 (0.52,0.48)	0.62 (0.64,0.60)	0.52 (0.53,0.51)
Mother highest qualification								
No formal qualifications	27672	0.48 (0.51,0.46)	0.61 (0.63,0.58)	0.68 (0.70,0.66)	27675	0.48 (0.51,0.46)	0.61 (0.63,0.58)	0.68 (0.70,0.66)
Secondary school	67047	0.72 (0.75,0.69)	0.82 (0.85,0.79)	0.83 (0.85,0.81)	67047	0.72 (0.75,0.69)	0.82 (0.85,0.79)	0.83 (0.85,0.81)
Bachelors degree	41901	0.81 (0.85,0.78)	0.84 (0.87,0.81)	0.86 (0.88,0.84)	41901	0.81 (0.85,0.78)	0.84 (0.87,0.81)	0.86 (0.88,0.84)
Postgraduate degree	57570	-	-	-	57570	-	-	-
Father highest qualification								
No formal qualification	26712	0.65 (0.68,0.61)	0.73 (0.76,0.70)	0.82 (0.85,0.79)	26712	0.65 (0.68,0.61)	0.73 (0.76,0.70)	0.82 (0.85,0.79)
Secondary school	51177	0.86 (0.91,0.82)	0.91 (0.94,0.88)	0.90 (0.93,0.88)	51177	0.86 (0.91,0.82)	0.91 (0.94,0.88)	0.90 (0.93,0.88)
Bachelors degree	47388	0.99 (1.04,0.94)	0.98 (1.02,0.94)	1.06 (1.10,1.04)	47388	0.99 (1.04,0.94)	0.98 (1.02,0.94)	1.06 (1.10,1.04)
Postgraduate degree	39450	-	-	-	39450	-	-	-
Member of household receives benefit income								
No	159069	-	-	-	158679	-	-	-
Yes	51777	0.57 (0.59,0.55)	0.65 (0.66,0.63)	0.66 (0.67,0.65)	51720	0.56 (0.58,0.55)	0.64 (0.66,0.63)	0.66 (0.67,0.65)
Family circumstances								

Age of mother at child's birth								
<20	14313	0.48 (0.51,0.46)	0.56 (0.59,0.54)	0.64 (0.66,0.62)	14313	0.48 (0.51,0.46)	0.56 (0.59,0.54)	0.64 (0.66,0.62)
20-24	41889	0.63 (0.66,0.61)	0.69 (0.72,0.67)	0.75 (0.77,0.74)	41889	0.63 (0.66,0.61)	0.69 (0.72,0.67)	0.75 (0.77,0.74)
25-29	55800	0.83 (0.86,0.79)	0.88 (0.90,0.85)	0.88 (0.91,0.87)	55800	0.83 (0.86,0.79)	0.88 (0.90,0.85)	0.88 (0.91,0.87)
30-34	66297	-	-	-	66297	-	-	-
35+	58977	0.90 (0.93,0.87)	0.89 (0.92,0.86)	0.95 (0.97,0.93)	58974	0.90 (0.93,0.87)	0.89 (0.92,0.86)	0.95 (0.97,0.93)
Father on birth certificate								
No	12612	0.56 (0.59,0.53)	0.61 (0.64,0.59)	0.60 (0.62,0.57)	12612	0.56 (0.59,0.53)	0.61 (0.64,0.59)	0.60 (0.62,0.57)
Yes	224664	-	-	-	224664	-	-	-
Mother speaks English								
No	3483	0.81 (0.90,0.72)	1.00 (1.10,0.92)	0.56 (0.60,0.53)	3483	0.81 (0.90,0.72)	1.00 (1.10,0.92)	0.56 (0.60,0.53)
Yes	196248	-	-	-	196248	-	-	-
Housing								
Urban	224976	-	-	-	215775	-	-	-
Rural	36630	1.05 (1.09,1.01)	1.03 (1.06,1.00)	1.59 (1.61,1.54)	35838	0.93 (0.96,0.89)	0.95 (0.98,0.93)	1.54 (1.59,1.52)
Household size								
2-4 people	121098	-	-	-	120852	-	-	-
5-7 people	77961	0.74 (0.76,0.71)	0.75 (0.76,0.72)	0.76 (0.77,0.75)	77808	0.74 (0.76,0.71)	0.74 (0.76,0.72)	0.76 (0.77,0.75)
8+ people	11784	0.42 (0.44,0.40)	0.51 (0.53,0.49)	0.36 (0.37,0.34)	11742	0.42 (0.44,0.40)	0.51 (0.53,0.49)	0.36 (0.37,0.34)

Own home	112581	-	-	-	112458	-	-	-
Rented home	94146	0.56 (0.57,0.54)	0.63 (0.65,0.62)	0.71 (0.72,0.69)	93840	0.56 (0.58,0.54)	0.64 (0.65,0.63)	0.71 (0.72,0.70)
Number of residence changes age 0-4								
None	61761	-	-	-	62412	-	-	-
1	57459	2.86 (2.94,2.78)	2.13 (2.17,2.08)	1.33 (1.37,1.30)	47994	1.16 (1.22,1.12)	1.01 (1.04,0.98)	0.90 (0.92,0.88)
2	42891	2.86 (2.94,2.70)	2.00 (2.08,1.92)	1.25 (1.28,1.22)	31935	0.96 (1.00,0.92)	0.85 (0.88,0.81)	0.83 (0.85,0.81)
3	28653	2.33 (2.44,2.22)	1.67 (1.72,1.61)	1.15 (1.18,1.11)	20745	0.85 (0.90,0.81)	0.73 (0.76,0.70)	0.78 (0.81,0.76)
4	18810	2.04 (2.13,1.92)	1.41 (1.47,1.37)	1.08 (1.11,1.04)	32235	0.66 (0.68,0.63)	0.60 (0.62,0.58)	0.76 (0.79,0.75)
5+	30447	1.56 (1.61,1.49)	1.16 (1.20,1.12)	1.05 (1.09,1.03)	62412	1.37 (1.43,1.32)	1.18 (1.22,1.14)	0.99 (1.01,0.97)
Health status								
Mother smoking status								
Regular smoker	38457	0.56 (0.57,0.53)	0.63 (0.65,0.61)	0.78 (0.79,0.76)	38460	0.56 (0.57,0.53)	0.63 (0.65,0.61)	0.78 (0.79,0.76)
Ex smoker	45420	0.94 (0.98,0.90)	0.90 (0.93,0.88)	1.08 (1.10,1.05)	45420	0.94 (0.98,0.90)	0.90 (0.93,0.88)	1.08 (1.10,1.05)
Never smoked	111219	-	-	-	111219	-	-	-
Birthweight								
<2500g	14049	0.57 (0.60,0.55)	0.73 (0.76,0.70)	0.87 (0.90,0.84)	14049	0.57 (0.60,0.55)	0.73 (0.76,0.70)	0.87 (0.90,0.84)
2500-4000g	187242	-	-	-	187239	-	-	-
>4000g	34746	1.01 (1.05,0.97)	0.96 (0.99,0.93)	1.04 (1.06,1.01)	34749	1.01 (1.05,0.97)	0.96 (0.99,0.93)	1.04 (1.06,1.01)

Gestation								
<37 weeks	17922	0.60 (0.63,0.57)	0.76 (0.79,0.73)	0.88 (0.91,0.85)	17922	0.60 (0.63,0.57)	0.76 (0.79,0.73)	0.88 (0.91,0.85)
37-42 weeks	217128	-	-	-	217128	-	-	-
>42 weeks	1443	1.00 (1.19,0.85)	0.97 (1.11,0.84)	0.67 (0.75,0.61)	1443	1.00 (1.19,0.85)	0.97 (1.11,0.84)	0.67 (0.75,0.61)
Child referred for disability support assessment								
No	261408	-	-	-	247875	-	-	-
Yes	4473	0.46 (0.50,0.43)	0.46 (0.49,0.43)	0.61 (0.65,0.57)	4401	0.34 (0.37,0.32)	0.38 (0.40,0.36)	0.56 (0.60,0.53)
Number of quarters enrolled with GP age 0-4								
0-3	25407	0.16 (0.17,0.16)	0.23 (0.24,0.22)	0.41 (0.42,0.39)	16215	0.16 (0.17,0.16)	0.20 (0.21,0.19)	0.42 (0.44,0.41)
4-7	41286	0.74 (0.77,0.72)	0.81 (0.83,0.78)	0.91 (0.93,0.89)	42645	0.53 (0.55,0.51)	0.54 (0.55,0.52)	0.83 (0.85,0.81)
8-11	90621	0.95 (0.98,0.92)	0.97 (1.00,0.94)	0.99 (1.01,0.97)	95298	0.76 (0.79,0.74)	0.78 (0.80,0.76)	0.98 (1.00,1.00)
12+	93174	-	-	-		-	-	-
Number of hospital admissions age 0-4								
None	104382	-	-	-	108081	-	-	-
1 to 2	104280	2.17 (2.22,2.13)	1.75 (1.82,1.72)	1.35 (1.37,1.32)	111288	1.32 (1.35,1.28)	1.23 (1.27,1.20)	1.14 (1.16,1.12)
3 to 5	21528	1.85 (1.92,1.79)	1.64 (1.72,1.59)	1.32 (1.35,1.27)	22668	1.06 (1.11,1.01)	1.11 (1.15,1.06)	1.09 (1.11,1.05)
6+	9834	1.23 (1.32,1.18)	1.19 (1.25,1.14)	1.12 (1.16,1.08)	10242	0.73 (0.77,0.69)	0.82 (0.86,0.78)	0.94 (0.98,0.91)

Total days in hospital age 0-4								
None	134751	-	-	-	141108	-	-	-
1 to 9	96537	1.92 (1.96,1.85)	1.59 (1.61,1.54)	1.27 (1.30,1.25)	102060	1.23 (1.27,1.20)	1.16 (1.19,1.14)	1.11 (1.12,1.09)
10 to 19	5022	1.28 (1.41,1.19)	1.22 (1.32,1.14)	0.98 (1.03,0.93)	5268	0.83 (0.91,0.77)	0.90 (0.96,0.84)	0.85 (0.90,0.81)
20+	3714	0.81 (0.88,0.75)	0.84 (0.91,0.78)	0.82 (0.88,0.77)	3843	0.53 (0.58,0.49)	0.63 (0.67,0.58)	0.72 (0.77,0.68)
Total number of ED visits age 0-4								
None	205911	-	-	-	215601	-	-	-
1 to 2	31854	1.20 (1.37,1.06)	0.96 (1.06,0.87)	0.63 (0.69,0.58)	34218	0.99 (1.02,0.95)	0.93 (0.95,0.90)	0.69 (0.71,0.68)
3+	2262	0.98 (1.01,0.96)	0.98 (1.00,0.96)	0.99 (1.01,0.98)	2457	0.85 (0.95,0.75)	0.76 (0.85,0.69)	0.58 (0.63,0.54)

Appendix 2

Percentage of children completing each component of B4SC, by year

	% of children completing check			
B4 School check	2011/12	2012/13	2013/14	2014/15
Vision	86.8	88.7	90.7	91.8
Hearing	86.8	88.6	90.6	91.8
Dental	79.4	82.1	86.7	88.4
Growth	79.4	82.1	86.7	88.4
Immunisation	79.1	81.9	86.3	87.9
PEDS	79.4	82.1	86.6	88.4
SDQP	79.3	81.9	86.5	88.2
SDQT	52.9	56.5	59.8	61.4

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1 (title)
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5,6
Objectives	3	State specific objectives, including any prespecified hypotheses	8
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	9-11
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	10-11
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	11-15
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	11-15
Bias	9	Describe any efforts to address potential sources of bias	*11, APPENDIX 2*
Study size	10	Explain how the study size was arrived at	11
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11-15
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	15-16
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	11, APPENDIX 2
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11
		(b) Give reasons for non-participation at each stage	11
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12-14, Tables 2 and 3
		(b) Indicate number of participants with missing data for each variable of interest	Tables 2 and 3
Outcome data	15*	Report numbers of outcome events or summary measures	Tables 2 and 3
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Tables 2 and 3
		(*b*) Report category boundaries when continuous variables were categorized	11-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	APPENDIX 2
Discussion			
Key results	18	Summarise key results with reference to study objectives	19
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	19-20
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	20-21
Generalisability	21	Discuss the generalisability (external validity) of the study results	19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	23

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.