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ETHNIC DIFFERENCES IN THE USE AND EXPERIENCE OF CHILD HEALTHCARE SERVICES IN NZ:

AN EMPIRICAL EXAMINATION

2020

AUTHORS

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DISCLAIMER

The views and interpretations in this report are those of the researchers and not the Ministry of Social Development.

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EXECUTIVE SUMMARY

This report focused on two main research aims using data from the *Growing Up in New Zealand* (GUiNZ) birth cohort:

1. To examine ethnic differences in life-course trajectories in the use and experience of healthcare services in early childhood years (namely immunisation, dental checks and use of GPs)
2. To quantify the contribution of relevant explanatory factors to ethnic differences.

Current policy indicates there should be, in terms of associated direct costs, equitable access by ethnicity for healthcare services. However, empirical evidence points to persistent ethnic gaps in several domains. For example, the data highlighted that Māori have the lowest immunisation rates, across a number of time points in early childhood – despite having a higher antenatal intention to immunise relative to NZ European. Further to that, NZ European are much more likely to have their first-choice lead maternity caregiver (LMC) and use child dental services compared to all ethnicities.

This research explored the underlying mechanisms behind ethnic differences in the use and experience of child healthcare services via econometric approaches. First, a multivariate regression analysis was used to adjust raw ethnic gaps in child health care utilisation by relevant covariates. This included a range of factors, encompassing mobility, socio-economic status, mother and child characteristics, household characteristics and other social aspects. Second, a decomposition analysis was used to assess the proportion of each ethnic gap that can be explained, as well as the main drivers behind the explained component. The analysis for both econometric approaches was repeated for each data time point available, which included antenatal, 9 months, 2 years and 4 years post-birth.

The following findings emerged:

- There is consistent evidence that Asian and Pacific peoples have a higher likelihood of child immunisation relative to NZ Europeans and Māori. This was evident at both their 15 month and age 4 immunisations, as well as their antenatal intention. The one time point where Pacific peoples had a lower rate relative to NZ European was for receiving all first-year immunisations on time.
- For a number of potential individual and household predictors of healthcare service utilisation, the association is time-variant across early childhood. For example, socio-economic status appears highly relevant for timely immunisations in a child's first year, but is then insignificant for the 15 month immunisations and those at age 4.
- Social factors play a key role. This included discouragement or encouragement regarding child immunisation. When broken down by source, discouragement by family has the largest marginal effect, followed by health professionals; whereas for encouragement, medical professionals have the largest positive influence.
- Perceived ethnically motivated discrimination by a health professional was significant with respect to reducing the likelihood of achieving first choice LMC, and also reducing satisfaction levels with child's GP.
- Some ethnic gaps were largely unexplained, despite the wealth of factors employed as independent variables in our analysis. This included understanding why Pacific mothers are much less likely to achieve their first choice LMC compared to NZ Europeans; and also understanding the ethnic gaps for both Māori and Pacific peoples relative to NZ Europeans concerning dental service use.

1. INTRODUCTION

The primary objective of this study is to explore ethnic disparities during childhood in the use and experience of healthcare services in NZ. The specific focus is on immunisation, dental checks and the use of GPs. Current policy indicates that there should be equitable access by ethnicity for these healthcare services, in terms of associated direct costs. This is based on free doctor visits for children under the age of 14, free National Immunisation Schedule vaccines, and free dental care until Year 8 of school (and through a contracted provider until 18 years of age). Despite these policies, there is extensive acknowledgement and evidence that ethnic gaps, particularly for Māori[2] and Pacific peoples, persist in these domains.

Underutilisation of preventive services (such as immunisation) during early childhood often exposes children to greater future health risks that can result in several adverse health outcomes in the long-run (see Ellison-Loschmann & Pearce 2006; Grant, Turner & Jones 2009; Lewis & Upsdell 2018; Dicker et al. 2019). For example, Hobbs et al (2017) find evidence of increasing rates of infectious disease hospitalisation rates for Māori and Pacific pre-school children, and importantly notes that for the Pacific population, delayed immunisation was strongly associated with this health outcome.

With respect to NZ evidence on ethnic differences in the use and experience of healthcare services of interest in this study, some descriptive pieces form the limited literature in this space. These studies provide associational evidence regarding individual and household characteristics and the use of the relevant healthcare service, particularly for immunisation rates. This study contributes to the literature with a focus on the longitudinal trajectory in early childhood years, as well as an exploration of key drivers to provide policy insights.

[2] With respect to Māori, He Korowai Organa: Māori Health Strategy sets the overarching framework to guide better health outcomes for Māori and to support the Ministry of Health and District Health Boards (DHBs) to achieve this.

To this end, we employ a contemporary birth cohort data set (GUiNZ), which tracks both child and household information from the antenatal period through the early childhood years. We focus on data up to the age of 4 years, and conduct our analysis with two specific research objectives in mind:

Aim 1 – To examine ethnic differences in life-course trajectories in the use and experience of three child healthcare services (namely immunisation; dental checks; and use of GPs).

Aim 2 – To quantify the contribution of relevant explanatory factors to explaining ethnic differences.

The first research aim will provide associational evidence between a range of factors and our outcome measures of interest. These factors encompass aspects of mobility, socio-economic status, mother and child characteristics, household characteristics, and other social aspects (such as discrimination). The second research aim will then quantify the contribution of each of these sets of factors to understand what proportion of the ethnic gap they explain. This analysis will also signal how much of the ethnic gap is left as unexplained. Where data permits, the analysis for both aim 1 and 2 will cover several time points: antenatal; 9 months; 2 years; and 4 years.

The remainder of this paper is organised as follows: Section 2 provides a very brief scan of the relevant literature, with particular focus on literature motivating the inclusion of relevant variables in our analysis; Section 3 describes the data and variables used in this analysis; Sections 4 and 5 present the identification strategy and then results for each research aim consecutively; Section 6 describes the limitations and caveats that need to be acknowledged; while Section 7 provides an overall conclusion including key policy insights and direction for future research.

2. LITERATURE REVIEW

The NZ Health Survey provides snapshots of the health of New Zealanders, which includes key statistics on health behaviours, status and access to healthcare services for both adults (aged 15 and over) and children (aged zero to 14). These surveys therefore provide useful background context particularly regarding barriers to various forms of medical care. The most recent survey (2018/19) found that 22.5 percent of children aged zero to four had an unmet need for primary healthcare[3] and this indicator had been fairly static since the 2011/12 survey. Across children aged zero to 14, the risk of having an unmet need for primary healthcare for Māori as well as for Pacific children relative to the respective likelihood for Non-Maori and Non-Pacific children was higher (1.34 for Maori; 1.35 for Pacific Peoples). The survey also provided information on self-reported reasons for unmet need for healthcare, which included cost, childcare, lack of transport and inability to get a timely appointment. For children aged zero to four, the proportion where cost was indicated as a barrier was 1.2 percent. For barriers related to transport, childcare, and inability to get an appointment within 24 hours, the comparable proportions were 2 percent, 2.7 percent and 19.9 percent, respectively.[4]

In terms of the relevant literature for this research, there are a number of studies assessing which factors are associated with the use and experience of healthcare services in early childhood. It is noteworthy that many of them are focussed on immunisation, with scant evidence on the use and experience with respect to GPs and dental services. Allen & Clarke (2019) recently provided an evidence review on the factors potentially linked with immunisation coverage. Based on a review of the NZ and international literature, they argue

[3] This is defined as experiencing one or more of the following: unmet need for a GP due to cost; unmet need for after-hours medical centre due to cost; unmet need for a GP due to lack of transport; unmet need for after-hours medical centre due to lack of transport; unmet need for a GP due to lack of childcare; and an inability to get an appointment at usual medical centre within 24 hours.

[4] There have been minor changes in these statistics over time, with the proportion of the population identifying cost, transport or childcare as a barrier falling marginally (by between a half to one percentage point), and those indicating inability to get a timely appointment increasing by three percentage points since 2011/12.

that systemic barriers are the primary cause of under-immunisation, with these barriers being linked with socio-economic factors, living in a rural location, and parents juggling many responsibilities.

In terms of studies using GUiNZ data, there are a couple worth pointing out. Grant et al (2016) identify associations between antenatal intentions to immunise and the subsequent timeliness of immunisation in the first year. Their results highlighted that close to a quarter of first-time mothers in the sample were undecided at the time of their antenatal survey and that the antenatal period is the optimum time to improve information pathways to parents regarding immunisation. Veerasingam et al (2017), also use GUiNZ data, and focus on information received in the antenatal period and whether it was encouraging or discouraging towards immunisation. They found a positive relationship between receiving discouraging information and not receiving timely immunisations in the child's first year. It is important to recognise here that both studies provide particular aspects of factors linked with childhood immunisation. They do not control for the wider array of factors that can also be included. For instance, Grant et al (2016) control for individual and household characteristics, but not aspects linked with mobility, and discrimination, for example. Whereas Veerasingham et al (2017) focus on mainly sources of information, with limited consideration of other likely covariates at play. The aim of this study is to incorporate a wider breadth of factors in the empirical analysis (aspects of mobility, socio-economic status, mother and child characteristics, household characteristics, and other social aspects), and to assess their contribution at numerous stages (antenatal; 9 months; 2 years; and 4 years).

To identify relevant covariates that are usually associated with the use and experience of child healthcare services, we surveyed the related health literature. One of the most widely studied characteristics in this context is parental attributes including their education and economic wellbeing (Flore et. al 1999; Bauman et al 2006; Rosenkötter et al. 2012; Zukerman et al. 2015). For instance, while studying ethnic disparities in American children's health and use of health

services, Flores et al. (1999) emphasise the importance of adjusting the differences by parental education and family income. Further, using a child-parent sample from Germany, Rosenkötter et al. (2012) find that low parental education and parents' migratory background are associated with lower prevalence of participating in nationally recommended early recognition (of health conditions) examination for infants and toddlers but a higher probability of future referrals resulting from health deficits detected by screenings performed as school entry requirements. Interestingly, the authors also find that children belonging to migrant families have a higher likelihood of being immunised. With respect to the relationship between economic well-being and child health outcomes, researchers often use income as an indicator of economic condition. For example, in exploring the underlying reasons behind a positive relationship observed between parental income and child's subjective health, Reinhold & Jurges (2012) find evidence of underutilisation of child health care services among low-income families.

Additionally, some of the other important associated characteristics that can affect child healthcare service usage include family structure; immigration status; locational characteristics and residential mobility; and societal factors such as social stigma and demographic biases. Our detailed review of the existing empirical research allows us to select the potential predictors of use of healthcare services in early childhood in NZ based on available data.

Following the existing evidence on family structure, our study considers survey-specific measures of household size and mothers' partnership status (Heck & Parker 2002; Gorman & Braverman, J. 2008; Wallby et al. 2013). In addition, parents' migrant background has also been traditionally found to be strongly associated with healthcare service use (Guendelman et al. 2001; Javier et al. 2010; Rosenkötter et al. 2012). While the empirical evidence in this context appears to be quite divided, some of the key mechanisms that can help explain the observed trends in healthcare usage among immigrant families include countries of origin, socio-

economic status and linguistic barriers (Lindert et al. 2008; Ou et al. 2010). To broadly account for these attributes, we control for native born mothers in our regression analysis. Further, locational and mobility-based attributes are intended to represent parental accessibility to child health care services. Based on studies by Field & Briggs (2001) and Jelleyman & Spencer (2008), we incorporate survey-specific variables that represent frequency of residential relocations, use of personal transport, rural location, and even availability of health care services within parents' locality as indicators of location- and mobility-based characteristics. Finally, for external societal influences (see Ganatra & Hirve 1994; Spencer & Chen 2004; Halim et al. 2013), we include indicators of ethnically motivated unfair treatment by healthcare professionals and external sources of positive as well as negative inducements to vaccinate a child. In our post-childbirth analysis, we further control for enrolment in childcare services (as an additional measure of external social factors), which is often found to be positively associated with child immunisation (see Rosenkötter et al. (2012) who include kindergarten visits as a covariate). This positive link is likely observed because institutions like childcare services and kindergarten often require children to be sufficiently vaccinated to protect other enrolled pupils from preventable health disorders. Additionally, these childcare establishments can assist in informing and promoting awareness among parents about the importance of child vaccination.

3. DATA

The data used in our analysis is obtained from a birth cohort study that provides contemporary information on more than 6,000 NZ children and their families (Morton et al. 2018). Co-ordinated by University of Auckland's Centre for Longitudinal Research – He Ara ki Mua, GUiNZ data tracks growth and developmental information of the children of surveyed parents. The interviews are conducted via computer-assisted face-to-face as well as via telephone. The surveys document child and family-level information on health, family life, education, psychological development, neighbourhood and environment, and culture and identity. In our context, we use four data collection waves (DCW) that represent interviews that were carried out before childbirth (DCW0; antenatal); nine months post-childbirth (DCW1); when the child was 2 years old (DCW2); and 4 years old (DCW4).[5]

For each wave, we derive survey-specific variables related to the three outcomes of interest. Table 1 shows definitions and descriptive statistics of these outcome variables, along with information on the particular wave they are sourced from.

[5] Note that DCW4 was conducted when the children were 45 months old. Another survey (DCW5) was conducted when the children were 54 months old, and in the subsequent analysis, where appropriate a few variables from DCW5 are included in the regressions at 4 years old.

Table 1. Descriptive information of healthcare service use and experience

				Total sample		NZ European		Māori		Pacific peoples		Asian	
	Variable name	Definition	Wave	Mean	*N*	Mean	*N*	Mean	*N*	Mean	*N*	Mean	*N*
Immunisation	Antenatal intention to fully immunise	Dummy variable: 1 if intended to have child fully immunised; 0 otherwise	DCW0	0.81	6171	0.75	3322	0.82	852	0.94	877	0.92	886
	All first-year immunisations on time ΔΔ	Dummy variable: 1 if the 6-week, 3-month and 5-month immunisations were all given on time; 0 otherwise	DCW1	0.70	6668	0.71	3550	0.54	924	0.65	970	0.85	974
	Received 15-month immunisations	Dummy variable: 1 if child received their 15-month immunisation (partial or full); 0 otherwise	DCW2	0.94	6312	0.93	3533	0.92	840	0.97	833	0.99	867
	Received age 4 immunisations	Dummy variable: 1 if child received their age 4 immunisations (partial or full); 0 otherwise	DCW4	0.87	5951	0.85	3451	0.80	751	0.90	721	0.94	811
Dental	Dental visit (age 2)	Dummy variable: 1 if child has ever been to school dental therapist, mobile unit or dentist by age 2; 0 otherwise	DCW2	0.38	6308	0.39	3527	0.33	841	0.39	833	0.41	868
	Dental visit (age 4)	Dummy variable: 1 if child has ever been to school dental therapist, mobile unit or dentist by age 4; 0 otherwise	DCW4	0.86	5952	0.90	3450	0.79	750	0.75	724	0.84	811
General Practitioner	Choice on LMC (antenatal)	Dummy variable: 1 if type of LMC was first choice; 0 otherwise	DCW0	0.89	6645	0.91	3578	0.88	901	0.84	941	0.86	974
	Seen GP or any health professionals since becoming pregnant (antenatal)	Dummy variable: 1 if the mother has seen any family doctor or GP since she became pregnant; 0 otherwise	DCW0	0.72	6821	0.71	3608	0.67	950	0.77	1000	0.76	1003
	Satisfied with usual GP practice (age 9 months)	Dummy variable: 1 if very or completely satisfied with child's usual GP practice; 0 otherwise	DCW1	0.68	6252	0.68	3431	0.62	827	0.74	859	0.68	901
	Satisfied with usual GP practice (age 2)	Dummy variable: 1 if very or completely satisfied with child's usual GP practice; 0 otherwise	DCW2	0.67	5998	0.68	3357	0.61	784	0.69	793	0.66	830

Note: We use four data collection waves (DCW) from GUiNZ that represent interviews that were carried out before childbirth (DCW0; antenatal); nine months post-childbirth (DCW1); when the child was 2 years old (DCW2); and 4 years old (DCW4). The shaded cell in each row highlights the group with the lowest mean for each health service indicator. ΔΔ: Grant et al. (2016) define immunisation on time as vaccination received within 30 days of their due date.

The descriptives in Table 1 are presented for both the aggregate GUiNZ population, as well as the ethnic sub-groups of NZ European; Māori, Pacific peoples and Asian (based on self-prioritised ethnicity). Overall, 81% of pregnant women in the full sample reported, in the antenatal wave, that they intended to fully immunise their children. Interestingly, the lowest levels of intention to immunise were expressed by NZ Europeans at 75%, followed by Māori at 82%. With respect to actual immunisation, children of Māori mothers are the least likely to receive their first-year immunisations on time. As evident from the information in DCW1, just over half the children in this ethnic subgroup received their 6-week, 3-month and 5-month immunisations on time.

In terms of the two indicators for utilisation of dental services, the respective sample proportions show that Māori and Pacific children have the lowest likelihood of undertaking a dental visit by age 2, and also by age 4. For example, by age 4, 75% of Pacific children have completed at least one dental visit,[6] whereas the corresponding proportion for NZ European children is 90%.

As outcome indicators in our empirical analysis, we use four variables related to GP use. During the antenatal period, we focus on a binary indicator of whether the type of LMC was the first choice; and another binary indicator if the mother had seen a family doctor or GP since becoming pregnant.[7] The two other outcomes of interest are related to satisfaction with child's usual GP, and these are measured when the child is 9 months and 2 years. A value of 1 for either of these variables indicates the respondent was very or completely satisfied with child's usual GP practice, and 0 otherwise.

We show in the descriptives in Table 1 that compared to other ethnicities, during pregnancy, NZ European women are the most likely to have their first choice as LMC (91%). We also find

[6] Dental visits might be either due to experiences of dental health issues or a part of regular dental check-up. However, the survey does not provide any further details on the underlying reasons of dental visits.

[7] Note that caution needs to be undertaken when interpreting these variables - as individuals that see a LMC will not necessarily also need to see a GP when pregnant.

that Asian and Pacific peoples have comparatively higher proportions of mothers using a GP or other health professional's service during pregnancy (76 and 77% respectively). Māori mothers have the lowest proportion of respondents who are likely to be satisfied with their children's GP services (62% are very or completely satisfied when the child is 2 years old, and 61% is the corresponding proportion at age 4).

The survey-specific covariates used in this study can be broadly classified into: mother and child characteristics (incorporating information on child and mother's health condition and risky behaviour), socio-economic status (captured via mothers' education, employment and household income level); household attributes (indicated by household size, whether mother was born in NZ, and her partnership status); mobility (locational characteristics and access to personal transport); and other social aspects which include experience of discrimination and external sources of discouragement or encouragement regarding vaccination. Definitions and descriptives for these covariates are provided in Table 2 and are sourced from the antenatal wave (DCW0).[8]

Descriptives of the covariates from other time points (DCW1, DCW2 and DCW4) are provided in the Appendix in Tables A3, A4 and A5. As evident in the appendix, additional covariates are added where a particular survey wave provides further information deemed useful to include as a predictor of healthcare service use. For instance, DCW1 also includes a binary indicator within the 'mobility' umbrella of factors that captures whether most of the GP/ doctor /healthcare visits are within a local area (shown in Table A3). DCW4 included information on internet access at home (see Bouche & Migeot 2008), which is also included within the 'mobility' domain (shown in Table A5). All survey waves post-birth (DCW1, DCW2, and DCW4) include more details about the child born, such as their gender, and whether the child has

[8] As evident in the descriptives, the mothers in the GUiNZ survey appear to be have a high level of educational attainment. The prevalence of having a postgraduate degree is 18 percent. In comparison, based on Census 2013, the proportion of adult individuals with a post-graduate qualification appears to be around 6 percent. See http://archive.stats.govt.nz/Census/2013-census/profile-and-summary-reports/qstats-education-training/highest-qualification.aspx; Retrieved on May 25, 2020.

ongoing health concerns. DCW1 also permits the split of one continuous indicator that captures household size in DCW0 into two continuous indicators for number of people aged under 18 in the household, and number of people aged 18 or over in the household. Further to that, DCW2 and DCW4 allow inclusion of number of child's siblings in the household.

In terms of sample variability across each of the data waves, there are three main factors affecting the sample size and composition at each time point: (i) sample attrition, whereby respondents respond in the earlier DCWs and drop out over time; (ii) missing survey wave, whereby respondents miss one wave, but re-join at later collection waves; and (iii) missing information for relevant outcome indicators and / or covariates. With respect to the overall sample drop-out, several strategies were employed to improve retention. This included providing participants who missed the 9-month wave the option to re-join at a later wave (Morton et al. 2012). Further, in addition to the main cohort, there were 200 families who had children approximately six to 15 months older in age, and they experienced the survey tools first and provided valuable feedback which led to revisions in the measures and methods employed for the main survey group (Morton et al. 2014). These strategies likely helped with generally high satisfaction levels with the survey and minimised attrition (Morton et al. 2014), and as such the retention rate by the age 4 wave was 90 percent (Morton et al. 2017).

As shown in Table 2 and Appendix Tables A3 through to A5, our sample size hovers from a low of 4,520 in the antenatal wave, to 5,341 and 5,475 in the surveys at 9 months and 2 years respectively, ending with 4,832 for the survey at age 4. These variations in sample size are likely driven primarily by missing information for relevant variables, rather than sample attrition or missing particular waves. We do not impute information for missing indicators, given the assumptions required for this process. Rather we take note that the general composition of our samples for DCW0, DCW1 and DCW2 are fairly similar with respect to ethnic composition, indicating a low likelihood of sample variation biasing our empirical models in the forthcoming analysis. The ethnic composition in DCW4 is a little different

compared to earlier waves, in that the proportion of NZ Europeans is higher, while the proportion of Pacific peoples is lower. This change in sample composition is therefore important to acknowledge as a potential caveat affecting the external validity of findings from this survey wave.

Table 2. Definitions of ethnicity variables and covariates from antenatal survey

	Variable	Definition	Mean
Ethnicity	NZ European	Binary indicator for NZ European in self-prioritised ethnicity	0.593
	Māori	Binary indicator for Māori in self-prioritised ethnicity	0.113
	Pacific peoples	Binary indicator for Pacific peoples in self-prioritised ethnicity	0.114
	Asian	Binary indicator for Asian in self-prioritised ethnicity	0.145
Mother & child	First child	Binary indicator for whether child is the first born	0.410
	Current age	Mother's current age (in years)	30.772
	Current weight	Mother's current weight (in kg)	80.743
	Disability status	Binary indicator for whether mother has a long-term physical disability	0.060
	Smokes regularly	Binary indicator for whether mother smokes regularly	0.080
Socio-economic	Employment	Binary indicator of mother's employment (equals 1 if employed in a job for wages and salaries; 0 otherwise)	0.597
	Post-graduation	Binary indicator for whether mother has a post-graduate qualification (e.g. Honours, Masters, Doctorate)	0.180
	Household income <NZ$ 50K	Binary indicator for household income less than NZ$ 50,000	0.220
	Household income >=NZ$ 50K & <=100K	Binary indicator for household income between NZ$ 50,000 and NZ$ 100,000	0.398
Household	Partner	Binary indicator for whether mother currently has a partner	0.969
	NZ born	Binary indicator derived from mother's country of birth (equals 1 if NZ; 0 otherwise)	0.651
	Household size	Number of people residing in the same household as mother	2.520
Mobility	Self-driving	Binary indicator for mother's main personal transport (equals 1 if drove private/company car; 0 otherwise)	0.816
	Numbers of residential moves	Number of times mother moved in the past 5 years.	2.344
	Rural location	Binary indicator for whether mother lives in a rural area	0.080
Other social aspects	Discriminated against	Binary indicator for whether mother was a victim in the past of ethnically motivated unfair treatment (physical, verbal, and/or by a health professional).	0.222
	Discouraged to immunise	Binary indicator for whether during pregnancy mother received information that discouraged her to immunise child	0.151
	Encouraged to immunise	Binary indicator for whether during pregnancy mother received information that encouraged her to immunise child	0.391
	Observations		4520

4. RESEARCH AIM 1

4.1 Method

As described earlier, this research aim involves examining ethnic differences in life-course trajectories in the use and experience of three healthcare services (immunisation; dental checks; and use of GPs). The method employed here is a multivariate regression to explore the associational relationship between the covariates identified (within the domains of mother and child characteristics, socio-economic status, household characteristics, mobility, and other social aspects) in the GUiNZ data and our outcomes of interest shown in Table 1.

As the outcome variables are binary, we use non-linear models. For each survey wave t (DCW0, DCW1, DCW2, and DCW4), which captures early childhood life-course from antenatal period through to when the child is age 4, we specify the following reduced form model:

$$y_i = \mathbf{1}(\alpha + \beta\ \text{Ethnicity}_i + Z_i'\gamma + u_i > 0) \quad (1)$$

Where y_i is the indicator variable of interest related to mother i (note that there are only single child-mother pairs)[9]. As illustrated in Table 1, outcomes include four variables capturing immunisation intention and uptake; two indicators for dental service visits; and four variables encompassing both use of healthcare practitioners and satisfaction with those practitioners. Further, Ethnicity_i represents mother's self-prioritised ethnicity and Z_i' is a vector of all other individual-level characteristics of mother and child (as discussed in the previous section). Finally, u_i is the error term that captures unobserved endowments and $u_i \sim N(0, \sigma_u^2)$. Since y_i is binary, a normalization is required and we chose $\sigma_u^2 = 1$. The outcome probabilities are:

$$P_i(y_i = 1) = \Phi[(\alpha + \beta\ \text{Ethnicity}_i + Z_i'\gamma)(2y_i - 1)] \quad (2)$$

With Φ being the cumulative standard normal distribution function.

[9] For simplification, we have dropped the time identifier t as we do not treat the data as a panel.

4.2 Results

We present our regression results in Table 3 for outcomes sourced in the antenatal survey (DCW0); and Tables 4, 5, and 6 for the 9 months, 2 years and 4 years post-birth surveys (DCW1, DCW2, and DCW4). All tables present marginal effects from our probit estimations.

Antenatal survey

As shown in Table 3, we consider three outcomes of interest represented by binary indicators of mother's antenatal intention to fully immunise her child, whether the mother has seen a doctor/GP during pregnancy, and whether the mother was able to have her first choice LMC.

When compared to NZ European mothers (the reference group), we do not find any statistically significant marginal effect for Māori mothers across any of the three dependent variables. However, we do find that in comparison to the reference group, Pacific and Asian mothers are more likely to express their positive intention to fully immunise their child. This is represented by a 12 and 14 percentage points higher likelihood of full immunisation intention for mothers of Pacific and Asian ethnicity, respectively. These findings are further substantiated by the statistically significant negative marginal effects observed for 'NZ born' mothers who are more likely to be comprised of NZ Europeans and Māori.

Pacific and Asian mothers are also more likely to see a doctor or GP while they are pregnant (represented by an approximately 10 percentage point higher likelihood for each ethnic group compared to NZ Europeans), but are less likely to have their first choice LMC (indicated by a 7 percentage point lower likelihood compared to NZ Europeans).

Focusing on maternal characteristics, older mothers (indicated by a continuous measure of age) and mothers pregnant with their first child are less likely to have intentions to fully immunise. With respect to socio-economic conditions, when compared to families whose

annual household income exceeds NZ$ 100,000, mothers from lower income families are less likely to express their intention to fully immunise their children.

It also appears that accessibility to health services is an important driver of parental intention to immunise their child. For instance, we find that mothers with access to personal transport have a higher likelihood of intending to immunise and obtain their first choice LMC, while those in rural locations are less likely relative to their urban counterparts of intending to fully immunise and seeing a doctor or GP while pregnant.

Of great interest in Table 3 is the role of external social influences. In particular, we find for mothers who were discouraged from immunising their children, relative to those not experiencing this influence, these mothers have a 14 percentage point lower likelihood of intending to immunise their children. At the other end of the spectrum, mothers who received encouragement to immunise, had a 5 percentage point increase in the likelihood of intending to immunise relative to those that did not receive such encouragement. On further review of the finer detail provided in the survey, we find that the sources of discouragement and encouragement can be broadly classified into information received from family, friends, health practitioners (such as GP, midwife, antenatal classes), and social media (e.g., TV, radio, internet). We subsequently repeated our antenatal analysis to explore the individual contribution of each of these broad sources of discouragement and/or encouragement. We find that relative to the omitted category of social media, the sources of discouragement from family, friends, and health practitioners have a significantly negative impact on the probability of intending to immunise. Discouragement by family has the largest marginal effect, followed by health professionals and then friends (all statistically significant at the 1 percent level). For encouragement source categories, medical professionals have the largest positive influence

on intention to immunise, relative to the omitted category of social media (with the role of family and friends being statistically insignificant).[10]

Table 3. Probit regression results from the antenatal survey

		Intend to fully immunise		Seen doctor/ GP while pregnant		First choice LMC	
		SM = 0.809 (1)		SM = 0.794 (2)		SM = 0.875 (3)	
Ethnicity	Māori *(Omitted: NZ European)*	0.008	(0.019)	-0.026	(0.021)	0.008	(0.018)
	Pacific peoples	0.124***	(0.028)	0.096***	(0.026)	-0.065***	(0.019)
	Asian	0.140***	(0.023)	0.098***	(0.024)	-0.067***	(0.018)
	Other ethnicity	0.065**	(0.032)	0.016	(0.033)	0.009	(0.029)
Mother & Child	First child	-0.158***	(0.013)	0.020	(0.015)	-0.017	(0.012)
	Current age (years)	-0.005***	(0.001)	-0.004***	(0.001)	-0.001	(0.001)
	Current mother's weight (kg)	0.001**	(0.000)	0.001**	(0.000)	-0.001***	(0.000)
	Disability status	-0.004	(0.023)	0.049*	(0.026)	-0.028	(0.019)
	Smokes regularly	0.046*	(0.024)	-0.043*	(0.023)	-0.038**	(0.018)
Socio-economic	Employment	-0.002	(0.013)	-0.003	(0.014)	0.007	(0.011)
	Post-graduation	0.022	(0.015)	0.011	(0.016)	0.007	(0.014)
	Household income <NZ$ 50K (*Omitted >100K*)	-0.033*	(0.019)	-0.044**	(0.020)	-0.013	(0.016)
	Household income >=NZ$ 50K & <=100K	-0.024*	(0.013)	-0.020	(0.014)	-0.003	(0.012)
Household	Partner	-0.013	(0.033)	-0.047	(0.037)	0.029	(0.027)
	NZ born	-0.039***	(0.015)	0.012	(0.016)	0.001	(0.013)
	Household size (number)	0.007	(0.005)	0.002	(0.005)	0.004	(0.004)
Mobility	Self-driving	0.034**	(0.016)	0.010	(0.017)	0.022*	(0.013)
	Numbers of residential moves	-0.012	(0.003)	0.006	(0.004)	0.000	(0.003)
	Rural location	-0.048***	(0.019)	-0.055***	(0.021)	0.020	(0.020)
Other social	Discriminated against	-0.020	(0.013)	0.014	(0.015)	-0.021*	(0.012)
	Discouraged to immunise	-0.144***	(0.014)	-0.006	(0.018)	-0.017	(0.014)
	Encouraged to immunise	0.052***	(0.012)	0.037***	(0.013)	-0.001	(0.011)
	Observations	4520		4527		4527	

Notes: The above table presents marginal effects from Probit models. The robust standard errors are reported within parentheses. SM = Sample mean. ***, **, * denote the coefficients are significantly different from zero at the 1%, 5%, and 10% level respectively. The ethnicity information is derived from self-prioritised ethnicity.

[10] These additional results are available upon request.

Survey at 9 months

Next, in Table 4, we look at binary indicators of timely immunisation (at 6 weeks, 3 months and 5 months after birth) and mother's satisfaction with child's GP practice (1 if very or completely satisfied; 0 otherwise). The 9-month survey provides both self-reported child immunisation information as well as administrative vaccination records from the National Immunisation Register (NIR). We used the NIR administrative records in the following analysis, as a more objective measurement. Nonetheless, it is worth noting that our findings based on self-reported information on child immunisation are qualitatively similar to the results obtained using NIR-validated measures.

We find that in comparison to the reference group of NZ Europeans, children of Māori mothers are significantly less likely (by 6 percentage points) to receive these early childhood vaccinations on time. When compared to our results in the antenatal analysis, this finding provides some important insights into the existence of ethnic disparities in the sense that while there's no difference in maternal intentions regarding child immunisation between Māori and NZ European women, there's indeed a significant difference in their service use.

Consistent with our antenatal findings, children of Asian mothers are more likely (by around 9 percentage points relative to NZ Europeans) to have timely immunisation. For children of Pacific mothers, they are more likely (by approximately 4 percentage points relative to NZ Europeans) to receive these early immunisations on time; and they are the only ethnic group who are more likely to be satisfied with their child's usual GP practice.

In comparison with our antenatal analysis on maternal intention towards child immunisation, we also observe contrasting findings with respect to first born children and infants of older mothers, who are more likely to receive immunisation on time. The results with respect to first born children are consistent with the findings offered by Schaffer & Szilagyi (1995) who evaluate the likelihood of timely immunisation by children's birth order.

In a similar manner to what was found in the antenatal analysis, the 9-month survey shows the strong negative link between low socio-economic status and probability of immunisation. For example, for those in the lowest household income category, there is close to a 10 percentage point lower probability of timely immunisation by 9 months relative to the omitted group of households with income over $100,000. The low- and medium-income households are also less likely to be satisfied with their child's GP relative to their high income household counterparts.

With respect to mobility and accessibility indicators, mothers from families who move frequently are less likely to have their children immunised on time, as well as less likely to be satisfied with their child's GP. On the other hand, having the child's healthcare facility situated in a nearby local area is positively associated with timely immunisation during infancy.

Among the societal factors, while experiences of ethnic-related discrimination by a health professional did not significantly affect early childhood timely immunisation, it understandably had a negative marginal effect concerning satisfaction with the child's GP practice. Interestingly, going to a childcare service is associated with a greater likelihood of vaccinating on time, underlined by an increase in the probability by approximately 5 percentage points. A plausible explanation are the strict preventive guidelines that childhood service centres may require parents to follow in order to protect enrolled children's health and wellbeing.[11]

Looking at external influences of discouragement and encouragement, we continue to find a strong role for discouragement – close to 15 percentage points lower probability of vaccinating on time relative to those not discouraged. Our results with respect to these external incentives to immunise children conform to Veerasingam et al.'s (2017) findings who show that that compared to mothers who didn't receive any encouraging or discouraging information (the

[11] See the information in https://www.healthed.govt.nz/resource/immunisation-guidelines-early-childhood-services-and-primary-schools-%E2%80%93-english-version; Accessed on April 2, 2020.

reference group), receiving discouragement is negatively associated with the likelihood that child was immunised on time.

Table 4. Probit regression results from the survey at 9 months

		All first-year immunisations on time		Satisfied with usual GP practice	
		SM = 0.708 (1)		SM = 0.680 (2)	
Ethnicity	Māori *(Omitted: NZ European)*	-0.061***	(0.019)	-0.009	(0.022)
	Pacific peoples	0.039*	(0.023)	0.049**	(0.025)
	Asian	0.088***	(0.025)	-0.011	(0.024)
	Other ethnicity	0.066*	(0.035)	-0.013	(0.036)
Mother & Child	Girl	0.013	(0.012)	0.001	(0.013)
	Birthweight (grams)	-0.00002*	(0.00001)	-0.00001	(0.00001)
	First child	0.088***	(0.015)	-0.001	(0.017)
	Child health/developmental problem	-0.049***	(0.019)	0.004	(0.021)
	Mother's age	0.002**	(0.001)	0.002	(0.001)
	Mother's disability	0.025	(0.029)	-0.011	(0.032)
	Regular smoker	-0.026	(0.019)	-0.028	(0.021)
Socio-economic	Employment	-0.016	(0.013)	-0.030**	(0.014)
	Post-graduation	0.001	(0.017)	-0.024	(0.018)
	Household income <NZ$ 50K (*Omitted >100K*)	-0.099***	(0.018)	-0.038**	(0.020)
	Household income >=NZ$ 50K & <=100K	-0.070***	(0.015)	-0.040***	(0.016)
Household	Partner	0.013	(0.024)	0.005	(0.027)
	NZ born	-0.030*	(0.016)	-0.008	(0.017)
	Number of people >=18 years	0.000	(0.007)	0.001	(0.007)
	Number of people <18 years	-0.069***	(0.006)	0.001	(0.008)
Mobility	Numbers of residential moves	-0.012***	(0.004)	-0.012***	(0.004)
	Rural location	-0.019	(0.021)	-0.064***	(0.024)
	Local healthcare	0.036***	(0.013)	-0.029	(0.015)
	Self-driving	-0.005	(0.018)	0.020	(0.018)
Other social aspects	Discriminated against	-0.011	(0.014)	-0.064***	(0.015)
	Discouraged to immunise	-0.147***	(0.017)	-0.056***	(0.019)
	Encouraged to immunise	0.015	(0.013)	0.035***	(0.014)
	Childcare services	0.045***	(0.018)	0.002	(0.020)
	Observations	5384		5341	

Notes: The above table presents marginal effects from probit models. The robust standard errors are reported within parentheses. SM = Sample mean. ***, **, * denote the coefficients are significantly different from zero at the 1%, 5%, and 10% level respectively. The ethnicity information is derived from self-prioritised ethnicity

Finally, using the 9-month survey we also conducted ethnic and age-specific regressions (shown in Appendix A) for the outcome variable of all first-year immunisations of time. A number of findings remain consistent across ethnicities and age categories (we provide two categories of age 18 to 29 and age 30 and above), such as the positive marginal effect

associated with the child being first born. There are however some findings that differ across sub-groups. For instance, and worth noting, discouragement to immunise plays a strong role for both NZ European and Māori, but not Pacific and Asian.

Survey at age 2

The survey undertaken with the GUiNZ cohort when the child was 2 years old allows us to look at the use of child dental services for the first time in our analysis. This is in addition to mothers' self-reported indicators of child immunisation at 15 months and satisfaction with child's usual GP practice. It is important to note here, that our survey-based dental service indicator can be capturing a variety of factors. It can include those making use of the free dental visit afforded to children in early childhood, and/or it could also include children visiting due to dental problems.

We report the estimates of marginal effects in Table 5. We find some evidence of time-variant differences in the association between ethnicity and child immunisation indicators across surveys. For example, relative to NZ Europeans, Māori were equally likely to intend to immunise in the antenatal survey, were significantly less likely to have immunised in time by the 9-month survey, and equally likely again for the 15-month immunisations. Children of Pacific mothers are again the most likely to have been immunised according to the survey at age 2. Māori and Asian are the two ethnic groups unsatisfied with their usual GP practice, relative to NZ Europeans.

There are fewer factors that are significantly associated with immunisation at 15 months, compared to what was found at 9 months. Those that are statistically significant include, for example: greater likelihood if child is the firstborn offspring, attending childcare service, and encouraged to immunise; and lower likelihood if in a rural location and if discouraged from immunising.

With respect to undertaking a dental visit by age 2, Asian and other ethnicities are more likely relative to NZ European, while Māori and Pacific peoples are equally likely. The probability of attending is lower if it is the first child. Of note, socio-economic status plays a role, if the mother is employed, the probability is 5 percentage points lower than if not employed; and the probability is also lower for low- and medium-income households, relative to households with income over $100,000. If we were to speculate, then the first of these factors, employment, may be related to time constraints with respect to scheduling a dental appointment.

Table 5. Probit regression results from survey at age 2

		Received 15-month immunisations		Satisfied with usual GP practice		Ever been for dental visit	
		SM = 0.984 (1)		SM = 0.675 (2)		SM = 0.391 (3)	
Ethnicity	Māori *(Omitted: NZ European)*	0.000	(0.006)	-0.064***	(0.022)	-0.034	(0.023)
	Pacific peoples	0.034***	(0.012)	-0.006	(0.023)	0.034	(0.023)
	Asian	0.022**	(0.010)	-0.056**	(0.024)	0.067***	(0.025)
	Other ethnicity	-0.001	(0.009)	0.054	(0.038)	0.085**	(0.037)
Mother & Child	Girl	0.002	(0.003)	0.000	(0.013)	-0.010	(0.013)
	Birthweight (in grams)	-0.00001*	(0.00001)	-0.00001	(0.00001)	0.00001	(0.00001)
	First child	0.011**	(0.005)	-0.009	(0.016)	-0.130***	(0.016)
	Child health/developmental problem	-0.002	(0.006)	-0.038	(0.024)	-0.027	(0.024)
	Mother's age	0.000	(0.000)	0.002	(0.001)	0.001	(0.001)
	Mother's disability	-0.002	(0.008)	0.029	(0.032)	0.036	(0.033)
	Regular smoker	0.002	(0.006)	-0.017	(0.021)	-0.061***	(0.022)
Socio-economic	Employment	0.000	(0.004)	-0.015	(0.014)	-0.055***	(0.015)
	Post-graduation	0.000	(0.005)	0.025	(0.018)	0.016	(0.018)
	Household income <NZ$ 50K (*Omitted >100K*)	-0.007	(0.006)	-0.036*	(0.020)	-0.040**	(0.020)
	Household income >=NZ$ 50K & <=100K	0.000	(0.004)	-0.039**	(0.016)	-0.031*	(0.016)
Household	Partner	-0.009	(0.008)	-0.008	(0.024)	0.031	(0.025)
	NZ born	0.001	(0.005)	-0.018	(0.017)	0.021	(0.018)
	Number of siblings	0.003	(0.002)	0.000	(0.006)	0.005	(0.006)
Mobility	Numbers of residential moves	-0.001	(0.003)	0.006	(0.010)	-0.010	(0.010)
	Rural location	-0.009*	(0.005)	-0.104***	(0.023)	-0.027	(0.024)
	Self-driving	-0.021**	(0.010)	0.040*	(0.022)	0.032	(0.023)
Other social aspects	Discriminated against	-0.002	(0.006)	-0.056***	(0.022)	-0.028	(0.023)
	Discouraged to immunise	-0.018***	(0.005)	-0.034*	(0.020)	-0.017	(0.020)
	Encouraged to immunise	0.009**	(0.004)	0.026*	(0.014)	0.015	(0.014)
	Childcare services	0.008**	(0.004)	-0.013	(0.015)	0.037***	(0.015)
	Observations	5143		5332		5475	

Notes: The above table presents marginal effects from probit models. The robust standard errors are reported within parentheses. SM = Sample mean. ***, **, * denote the coefficients are significantly different from zero at the 1%, 5%, and 10% level respectively. The ethnicity information is derived from self-prioritised ethnicity.

Survey at age 4

Finally, in Table 6, we present estimates of marginal effects for our 4-years survey analysis. It is important to note, conditional on the data availability, the analysis here integrates information from both the 45-month (DCW4) and 54-month (DCW5) surveys. The two outcomes of interest include dichotomous indicators of immunisations due at age 4, as well as a dental visit by this age.

Regarding mothers' self-prioritised ethnicity, consistent with our earlier findings once again we see a statistically significant positive association between Asian as well as Pacific mothers and the likelihood of their child receiving immunisations due at age 4. Similar variables shown to be associated with immunisation at 9 months and age 2 also appear relevant at age 4. For instance, more likely to have immunised if first child and if they attended childcare services; less likely to have immunised if in a rural location, moved residential location frequently, and were discouraged from immunising.

With respect to undertaking a dental visit by age 4, the least likely ethnic groups are Māori and Pacific peoples (respectively, 4 and 6 percentage points lower likelihood relative to NZ Europeans). A dental visit is less likely if the mother is a regular smoker and the higher the frequency of residential relocation. On the other hand, dental visits are more likely if the mother is highly educated (with at least a postgraduate qualification), has a partner, and is NZ born. Finally, as with immunisation at age 4, a dental visit is more likely if the child attended childcare services – 6 percentage points more likely than those that didn't.

Table 6. Probit regression results from survey at age 4

		Received age 4 immunisations		Ever been for dental visit	
		SM = 0.864 (1)		SM = 0.888 (2)	
Ethnicity	Māori *(Omitted: NZ European)*	-0.009	(0.016)	-0.037***	(0.014)
	Pacific peoples	0.076***	(0.021)	-0.062***	(0.016)
	Asian	0.082***	(0.022)	0.000	(0.017)
	Other ethnicity	0.032	(0.029)	0.075**	(0.031)
Mother & Child	Girl	0.001	(0.010)	-0.003	(0.009)
	Birthweight (in grams)	0.00002**	(0.00001)	0.00001	(0.00001)
	First child	0.055***	(0.011)	-0.003	(0.011)
	Child health concern	0.000	(0.010)	0.003	(0.009)
	Common illness	0.005	(0.011)	0.006	(0.010)
	Mother's age	0.000	(0.001)	0.002*	(0.001)
	Mother's disability	-0.003	(0.022)	0.045*	(0.024)
	Regular smoker	0.003	(0.017)	-0.031**	(0.014)
Socio-economic	Employment	0.016*	(0.010)	-0.007	(0.009)
	Post-graduation	0.017	(0.014)	0.044***	(0.014)
	Household income <NZ$ 50K	-0.030	(0.023)	-0.012	(0.021)
	Household income >=NZ$ 50K & <=100K	-0.031	(0.024)	-0.010	(0.022)
Household	Partner	0.030*	(0.017)	0.037***	(0.014)
	NZ born	-0.017	(0.014)	0.025**	(0.012)
	Number of siblings	-0.014***	(0.004)	-0.001	(0.004)
Mobility	Numbers of residential moves	-0.013***	(0.005)	-0.025***	(0.004)
	Rural location	-0.031**	(0.015)	0.010	(0.016)
	Self-driving	0.024	(0.016)	0.016	(0.015)
	Internet access	-0.031	(0.021)	0.002	(0.017)
Other social aspects	Discriminated against	-0.020	(0.018)	-0.011	(0.015)
	Discouraged to immunise	-0.065***	(0.014)	-0.008	(0.014)
	Encouraged to immunise	0.006	(0.011)	-0.001	(0.010)
	Childcare services	0.069***	(0.019)	0.060***	(0.017)
	Observations	4844		4832	

Notes: The above table presents marginal effects from probit models. The robust standard errors are reported within parentheses. SM = Sample mean. ***, **, * denote the coefficients are significantly different from zero at the 1%, 5%, and 10% level respectively. The ethnicity information is derived from self-prioritised ethnicity.

5. RESEARCH AIM 2

5.1 Method

Building on the descriptive evidence obtained from the probit analysis for aim 1, we next evaluate the contribution of the different covariates in explaining observed ethnic differences in indicators of use and experience of healthcare services. To identify the fraction of ethnic differences that can be explained by our covariates, our empirical strategy incorporates a decomposition technique that was conceptualized by Blinder (1973) and Oaxaca (1973) who study labour earnings disparity between males and females.[12] Since the conception of Blinder-Oaxaca decomposition technique, the methodology has been widely utilised to study outcome gaps (e.g. labour market outcomes like earnings) between two demographic groups of interest (defined by say sex, race, or ethnicity). The Blinder-Oaxaca model shows that in general, the difference in the mean of the outcome variables between the two groups of interest can be decomposed into an 'explained' part and an 'unexplained' portion. While the 'explained' part represents the share of the outcome differential that can be attributed to differences in observable characteristics between the two groups, the 'unexplained' portion incorporates the differences in unobservable characteristics (Jann, 2008).[13]

Given the dichotomous nature of our dependent variables, we use the Fairlie decomposition method (see Fairlie 2005) which extends the standard Blinder-Oaxaca decomposition method for application in non-linear models.[14]

[12] Blinder (1973) also studies wage differential between White and African American males.

[13] For instance, in the classic example of male-female wage differential, the explained difference can be captured by variation in observable characteristics such as education or schooling. On the other hand, the unexplained part has often been attributed to unmeasured factors such as labour market discrimination (Blinder 1973). However importantly, the unexplained difference can also emerge from disparities in other unobservable characteristics such as personal skills, productivity, motivation, etc.

[14] For our analysis, we employ a pooled probit specification by using the user-written 'Fairlie' package in Stata16 developed by Jann (2006). The pooled specification allows us to estimate the coefficients by pooling variables from both the groups compared.

For our analysis, we compare Māori and Pacific peoples respectively, to NZ Europeans. In general, the Fairlie decomposition model can be represented by:

$$\bar{Y}^{E} - \bar{Y}^{NE} = \left[\sum_{i=1}^{N^{E}} \frac{F(X_i^{E}.\hat{\beta}^{E})}{N^{E}} - \sum_{i=1}^{N^{NE}} \frac{F(X_i^{NE}.\hat{\beta}^{E})}{N^{NE}}\right] + \left[\sum_{i=1}^{N^{NE}} \frac{F(X_i^{NE}.\hat{\beta}^{E})}{N^{NE}} - \sum_{i=1}^{N^{NE}} \frac{F(X_i^{NE}.\hat{\beta}^{NE})}{N^{NE}}\right] \quad (3)$$

Where, $\bar{Y}^{E} - \bar{Y}^{NE}$ represents the actual difference in the outcome between NZ European (indexed by superscript *E*) and each of the non-NZ European groups (indexed by superscript *NE*). Indexed by group-specific superscripts, X, $\hat{\beta}$, and N represent the vector of the average values of covariates (used in aim 1 analysis), corresponding estimated regression coefficients and sample size, respectively.

The first summand on the right-hand side of equation represents the part of the ethnic gap that is 'explained' by ethnic group differences in distributions of the vector of covariates. The second term isn't straightforward to interpret and represents the 'unexplained' part - it incorporates the portion of the ethnic differences that is driven by across-group differences in unobserved influences.

5.2 Results

Māori compared to NZ European

In Table 7 we decompose the observed differences in Māori-NZ European outcomes across all four survey waves. We use the same survey-specific variables shown in Tables 3 through to 6. To ease interpretation, all estimates are collapsed within their respective category of characteristics - mother, child, socio-economic, household, mobility, and other social aspects. Therefore, Table 7 provides several points of interpretation – the total raw ethnic difference in each outcome of interest; how much of this ethnic difference can be explained by the covariates included; and how important each category of characteristics is in driving the proportion explained.

For example, as shown in Table 7 we observe that the raw ethnic difference in the antenatal intention to immunise is just -0.059, and that approximately 86 percent of the gap can be explained by the covariates incorporated in our analysis (-0.051 out of -0.059). Further, a substantial proportion of the 'explained' difference is driven by the mothers' characteristics. Recall that this includes indicators of mothers' age, weight, long-term disability status, smoking status and whether this was their first child.

For the 9-month survey decomposition analysis, while the raw ethnic gap for timely immunisations in the child's first year has grown from the antenatal survey, much of the gap is explained by the independent variables included. The total explained is approximately 68 percent (0.115 out of 0.169) in this survey wave, with household characteristics playing a primary role in accounting for more than half of the explained contribution. Given that household characteristics include factors such as whether the mother has a partner and number of siblings in the household, these may be potential indicators of how busy the mother is. For example, partner status reflects whether the mother is a single parent, and thus having to juggle household activities and responsibilities on their own.

Table 7. Decomposition of the ethnic differences, NZ European-Māori comparison

	Antenatal			9 months		2 years			4 years	
	Intend to fully immunise	Seen doctor/ GP while pregnant	First choice LMC	All first-year immunisations on time	Satisfied with usual GP practice	Received 15-month immunisations	Satisfied with usual GP practice	Ever been for dental visit	Received age 4 immunisations	Ever been for dental visit
Vector of covariates	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Mother	-0.040***	-0.007	0.014*	0.013*	0.008	-0.003**	0.005	0.011	-0.003	0.010**
Child	-0.017***	0.004*	-0.001	0.007***	0.002	0.003*	-0.003	-0.013***	0.008***	0.001
Socio-economic	0.016***	0.009	0.008	0.029***	0.007	0.005*	0.022***	0.009	0.002	0.006***
Household	-0.004	-0.001	-0.008	0.068***	0.004	-0.005*	0.009	-0.004	0.017***	-0.001
Mobility	0.001	-0.003	0.002	-0.001	-0.001	-0.001	-0.006**	0.002	0.004	0.010***
Social	-0.008**	-0.010**	0.008**	-0.004	0.010**	-0.002	0.003	0.002	-0.008	0.005
Explained	-0.051	-0.007	0.023	0.115	0.029	-0.004	0.030	0.008	0.020	0.031
Unexplained	-0.008	0.021	-0.008	0.054	0.009	0.001	0.060	0.039	0.019	0.048
Total difference (NZ European – Māori)	-0.059	0.014	0.015	0.169	0.038	-0.003	0.090	0.047	0.039	0.079
$N_{European}$	2682	2682	2682	3165	3140	2976	3113	3201	3111	3100
$N_{Māori}$	513	513	513	672	657	644	672	696	563	563

Notes: The above table reports estimates of each of the vectors' contribution in explaining the observed differences in health outcomes between NZ Europeans and Māori. The non-linear decomposition employs a pooled probit model that considers only observations from the two ethnicities compared in the analysis**.** ***, **, * denote the coefficients are significantly different from zero at the 1%, 5%, and 10% level respectively.

At age 2, the ethnic gap in immunisations between Māori and NZ European is small, and fully explained by the covariates included. At age 4, the ethnic gap is marginally larger, and we find that approximately half is explained (0.020 out of a total of 0.039) – and again, primarily driven by household characteristics.

In terms of the GP-related outcomes, results vary depending on outcome of interest and time point. For instance, just over 76 percent of the ethnic gap in satisfaction with GP can be explained when the child is 9 months old, but this falls to 33 percent when the child is age 2. At the 9-month survey, social factors are the largest contributor towards the explained gap in satisfaction with GP practice. These factors include perceived discrimination in the health system, as well as external sources of both encouragement and discouragement towards immunisations.

The difference between NZ European and Māori use of a dental visit by age 2 is only 17 percent explained. Although by age 4 the numbers climb to 39 percent, a substantial portion of the gap is unexplained. An interpretation of this finding is that there are additional factors beyond the covariates used in this analysis that may be driving these ethnic differences in dental service use. Further qualitative analysis in this space would be a useful direction for future research.

Table 8. Decomposition of the ethnic differences, NZ European-Pacific peoples comparison

	Antenatal			9 months		2 years			4 years	
	Intend to fully immunise	Seen doctor/ GP while pregnant	First choice LMC	All first-year immunisations on time	Satisfied with usual GP practice	Received 15-month immunisations	Satisfied with usual GP practice	Ever been for dental visit	Received age 4 immunisations	Ever been for dental visit
Vector of covariates	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Mother	-0.034***	-0.016	0.005	0.009*	0.011***	0.000	0.012**	0.015***	0.002	0.011***
Child	-0.024***	0.003	-0.004***	0.016***	0.005	0.005**	-0.002	-0.020***	0.015***	-0.000
Socio-economic	0.032***	0.023**	0.012**	0.035***	0.000	0.008	0.009	0.003	0.003	0.006*
Household	-0.029**	-0.002	-0.006	0.078***	-0.013	-0.001	-0.011	0.003	0.026***	0.014**
Mobility	-0.002	0.000	0.002	-0.012**	-0.017***	-0.002	-0.009***	-0.003	-0.005*	0.002
Social	-0.035***	-0.015***	0.003	-0.019***	-0.009*	-0.006**	-0.003	0.001	-0.013	0.002
Explained	-0.093	-0.006	0.003	0.107	-0.023	0.004	-0.003	-0.001	0.029	0.035
Unexplained	-0.097	-0.098	0.093	-0.052	-0.036	-0.024	0.007	-0.031	-0.086	0.086
Total difference (NZ European – Pacific)	-0.190	-0.104	0.096	0.055	-0.059	-0.020	0.004	-0.032	-0.057	0.121
$N_{European}$	2683	2683	2683	3165	3140	2976	3113	3201	3103	3100
$N_{Pacific\ peoples}$	514	514	514	630	630	632	647	660	422	424

Notes: The above table reports estimates of each of the vectors' contribution in explaining the observed differences in health outcomes between NZ Europeans and Pacific peoples. The non-linear decomposition employs a pooled probit model that considers only observations from the two ethnicities compared in the analysis. ***, **, * denote the coefficients are significantly different from zero at the 1%, 5%, and 10% level respectively.

Pacific peoples compared to NZ European

Table 8 repeats the decomposition analysis shown in Table 7, but with the ethnic comparison of Pacific peoples to NZ European. As shown by the negative raw difference in antenatal intention to immunise, Pacific mothers are more likely than their NZ European counterparts to express an intention to fully immunise when pregnant. However, this pattern is reversed at the 9-month survey, with a positive sign on the raw difference in actual timely immunisations during the child's first year. Interestingly, the difference is more than fully explained by the covariates included in the decomposition analysis. To simply interpret this, it indicates that if Pacific households had the same observable characteristics/household resources of the population represented by the pooled sample of both the ethnic groups, their immunisation rate at the 9-month stage would have exceeded that of NZ Europeans.

In terms of GP-related outcomes, Pacific mothers are much less likely to achieve their first choice for LMC compared to NZ Europeans. However, the individual and household level variables included in the model explain only 3 percent of this ethnic difference. This presents as another area where further qualitative analysis may be useful.

Finally, the largest ethnic gap in dental service use is evident by age 4 between NZ Europeans and Pacific peoples. The explained proportion is 29 percent (0.035 explained out of a total difference of 0.121), and this is primarily driven by household characteristics, followed closely by maternal characteristics.

6. LIMITATIONS

The analysis provided in aims 1 and 2 provides a range of insights into the understanding of ethnic disparities in usage of child healthcare services in NZ. Nonetheless, there are a number of limitations that must be acknowledged. First, the findings presented are based on a survey of a selected sample of mothers whose socio-economic characteristics may not be representative of the whole of NZ. For example, as noted before, on average, the academic qualification level of the mothers in our sample (aged 18 to 41) appears to be higher than the national average[15]. As such it would be useful for future analysis to focus on a wider population-based sample of mothers using information from the Integrated Data Infrastructure, such as Census data and the Ministry of Health's National Immunisation Register.

Secondly, given the saturated nature of the multivariate regression models employed in our empirical analyses, it is plausible that some of our covariates are highly correlated, thereby potentially affecting both the estimation and precision of our regression coefficients. However, after performing standard additional diagnostics on this front, we found no statistical evidence in support of the presence of multicollinearity.[16]

The final limitation worth pointing out is that the results from our two main research objectives do not represent causal relationships. Our findings do hopefully pave the way for future research to exploit exogenous variation in independent variables, for example a change in policy that provides additional inducements to immunise children. Moreover, a natural extension of this study would be to look at the state dependence in outcome variables of

[15] This is based on aggregate female qualification information from the 2013 Census, which is not an exact like-for-like comparison, but useful proxy.

[16] First, we examined pairwise correlations between our independent variables and did not find any correlation ratios beyond 0.70 between any pair of covariates. Second, using a linear specification with respect to the measure of maternal intention to fully immunise her child, we compute the variance inflation factor (VIF). The resultant VIF is substantially lower than the recommended value of 10 (Hair et al. 1998).

interest (like immunisation) to evaluate the persistence of ethnic group-specific use of child healthcare services. The feasibility of this approach would be adequately supported by taking advantage of the longitudinal aspect of GUiNZ data and is already the subject of planned future research.[17]

[17] Future research on this front is planned via a Health Research Council grant.

7. CONCLUSIONS

This study uses GUiNZ data to provide insights regarding life-course ethnic differences in the use and experience of child healthcare services in NZ. The findings presented have several policy-relevant implications.

First, based on the raw descriptives provided in Table 1, NZ European mothers have higher rates of child healthcare service usage in a number of indicators relative to other ethnic groups, especially Māori. For instance, the NZ European group is more likely to have their first choice LMC and use child dental services compared to all other ethnicities. Moreover, despite the fact that they have the lowest antenatal intention to immunise, NZ European also have higher child immunisation rates compared to Māori. Just over a half of Māori children had their 6-week, 3-month and 5-month immunisations on time; and the corresponding proportion for NZ Europeans was 71%. To explore the underlying mechanisms behind the range of ethnic differences, we employed two econometric approaches – a multivariate probit and a decomposition analysis.

The multivariate regression analysis was undertaken to fulfil the first research aim, i.e. examine ethnic differences in life-course trajectories for our outcomes of interest. This analysis essentially adjusts the crude ethnic gaps in the child health care utilisation by relevant covariates, including factors encompassing mobility, socio-economic status, mother and child characteristics, household characteristics and other social aspects.

One of the most consistent findings evolving out of research aim 1 is that Asian and Pacific peoples have a higher likelihood of child immunisation compared to NZ Europeans and Māori. This finding stands irrespective of time point, whether antenatal intention, immunisations in the first year, or at 15 months, or at age 4.

For most other independent variables used in the regression analysis, associations between particular individual or household characteristics and healthcare service usage often varied by time and relevant outcome variable of interest. For example, socio-economic status appears highly relevant for timely immunisations in a child's first year, but is statistically insignificant for receiving the 15-month immunisations, and mostly insignificant (bar employment status) for the age 4 immunisations.

There were a handful of factors that stood out as time-invariant influences across early childhood years. These included child's birth order and enrolment in childcare services, both with respect to child immunisation rates. Further to these, another set of factors found to be consistently important are particularly worth pointing out from a policy perspective. These are external societal influences, such as discouragement or encouragement regarding child immunisation. For example, we found mothers who were discouraged from immunising their children had a 14 percentage point lower likelihood of intending to do so; while at the other end of the spectrum those that were encouraged had a 5 percentage point increase in their likelihood intention. When broken down by source, discouragement by family has the largest marginal effect, followed by health professionals; whereas for encouragement, health professionals have the largest positive influence. Furthermore, in ethnic-specific models at age 9 months, it was found that discouragement had a significant negative marginal effect for NZ Europeans and Māori, and not Pacific peoples and Asians. Collectively, these findings present as clear potential candidates for policy levers.

Of further interest was another social factor included in the analysis: perceived ethnically motivated discrimination by a health professional. This factor was significant with respect to reducing the likelihood of achieving first choice of LMC, as well as reducing the satisfaction level with child's GP at both 9 months and 2 years. Discrimination is therefore a likely part of the story in understanding the very low levels of satisfaction Māori have with their child's usual

GP practice – just 62% and 61% very or completely satisfied when the child is age 2 and age 4 respectively.

For the second research objective, we examine the contribution of different sets of covariates to ethnic gaps with a focus on how much of the gap can be explained, and what are the primary drivers behind the explained component. For example, we found that the majority of the ethnic gap in the antenatal intention to immunise between NZ European and Māori could be explained by the independent variables included in the analysis, with a substantial portion of the explained difference being driven by mothers' characteristics (this encompassed mother's age, weight, disability status and indicator of smoking).

Another useful example of results from the decomposition analysis is that social factors (which include discrimination and discouragement by others) are the largest contributor to the NZ-European – Māori difference in satisfaction with child's GP at 9 months. This is consistent with findings from the first research aim.

In some instances, the independent variables included in the analysis over-explained the ethnic gap. This was the case for differences in NZ European – Pacific immunisation rates at the 9-month survey.

Finally, it is worth pointing out cases where the explained component was very low. This was the case in understanding why Pacific mothers are much less likely to achieve their first choice LMC compared to NZ Europeans; and also understanding the ethnic gaps for both Māori and Pacific peoples relative to NZ Europeans with regard to dental service use. Both these areas need further qualitative exploration, to understand what additional factors, not captured in the GUiNZ survey, play a role with these outcomes.

As indicated in the limitations section as well, future research can utilise this birth cohort to examine causal mechanisms and explore state dependence in outcomes of interest – particularly for immunisation, where there are four time points of data available.

8. APPENDIX A

Table A1 - Ethnic-specific analysis of all first-year immunisations on time (9-month survey)

	Variables	NZ European		Māori		Pacific peoples		Asian	
		SM = 0.715		SM =0.546		SM = 0.660		SM = 0.907	
Mother & Child	Girl	0.008	(0.015)	0.000	(0.037)	0.044	(0.036)	0.00	(0.026)
	Birthweight (in grams)	-0.00003**	(0.00001)	-0.00002	(0.00003)	0.00005*	(0.00003)	-0.00001	(0.00002)
	First child	0.075***	(0.021)	0.096**	(0.047)	0.200***	(0.049)	0.022	(0.036)
	Child health/developmental problem	-0.050**	(0.023)	0.052	(0.067)	-0.113*	(0.068)	-0.073	(0.056)
	Mother's age	0.002	(0.002)	0.006*	(0.004)	0.003	(0.004)	-0.001	(0.003)
	Mother's disability	0.031	(0.039)	-0.022	(0.078)	0.118	(0.142)	0.121	(0.079)
	Regular smoker	-0.018	(0.017)	-0.048	(0.040)	0.000	(0.045)	-0.094	(0.100)
Socio-economic	Employment	0.022	(0.020)	-0.042	(0.045)	0.075*	(0.043)	-0.018	(0.028)
	Post-graduation	0.021	(0.020)	-0.121	(0.086)	-0.077	(0.099)	-0.027	(0.034)
	Household income <NZ$ 50K (*Omitted >100K*)	-0.135***	(0.025)	-0.063	(0.060)	0.066	(0.067)	-0.039	(0.043)
	Household income >=NZ$ 50K & <=100K	-0.087***	(0.018)	-0.035	(0.057)	0.071	(0.065)	-0.046	(0.039)
Household	Partner	-0.004	(0.038)	0.036	(0.055)	-0.004	(0.053)	0.081	(0.080)
	NZ born	-0.002	(0.019)	-0.053	(0.123)	-0.028	(0.041)	-0.044	(0.062)
	Number of people >=18 years	-0.011	(0.013)	0.007	(0.016)	-0.002	(0.014)	0.001	(0.011)
	Number of people <18 years	-0.081***	(0.011)	-0.105***	(0.015)	-0.042***	(0.014)	-0.036	(0.021)
Mobility	Numbers of residential moves	-0.011**	(0.005)	-0.017	(0.011)	-0.015	(0.013)	-0.014	(0.009)
	Rural location	-0.012	(0.024)	0.036	(0.070)	-0.010	(0.197)	-	-
	Local healthcare	0.041**	(0.017)	0.074*	(0.043)	-0.017	(0.041)	0.013	(0.030)
	Drove car	-0.011	(0.027)	0.017	(0.052)	-0.038	(0.043)	0.002	(0.029)
Other social aspects	Discriminated against	-0.012	(0.020)	-0.057	(0.037)	-0.052	(0.044)	0.060*	(0.031)
	Discouraged to immunise	-0.170***	(0.021)	-0.159***	(0.055)	0.087	(0.078)	-0.087	(0.060)
	Encouraged to immunise	0.021	(0.018)	0.020	(0.039)	0.001	(0.037)	0.003	(0.026)
	Childcare services	0.084***	(0.024)	-0.019	(0.053)	-0.013	(0.063)	0.016	(0.045)
	Observations	3165		672		630		732	

Notes: The above table presents marginal effects from probit models. The robust standard errors are reported within parentheses. SM = Sample mean. ***, **, * denote the coefficients are significantly different from zero at the 1%, 5%, and 10% level respectively. The ethnicity information is derived from self-prioritised ethnicity.

Table A2 - Age-specific analysis of all first-year immunisations on time (9-month survey)

	Variables	18 ≤ Age < 30		Age 30 & above	
		SM = 0.687		SM = 0.726	
Ethnicity	Māori	-0.056**	(0.025)	-0.061**	(0.030)
	Pacific Peoples	0.041	(0.031)	0.031	(0.034)
	Asian	0.078**	(0.037)	0.091***	(0.034)
	Other Ethnicity	0.030	(0.056)	0.086**	(0.043)
Mother & Child	Girl	0.012	(0.018)	0.014	(0.016)
	Birthweight	-0.00002	(0.00002)	-0.00001	(0.00001)
	First child	0.100***	(0.022)	0.072***	(0.022)
	Child health/developmental problem	-0.013	(0.030)	-0.072***	(0.025)
	Mother's age	0.001	(0.003)	-0.002	(0.003)
	Mother's disability	-0.016	(0.045)	0.059	(0.039)
	Regular smoker	-0.025	(0.024)	-0.021	(0.031)
Socio-economic	Employment	-0.010	(0.021)	-0.024	(0.017)
	Post-graduation	-0.032	(0.032)	0.008	(0.019)
	Household income <NZ$ 50K (*Omitted >100K*)	-0.118***	(0.032)	-0.073***	(0.025)
	Household income >=NZ$ 50K & <=100K	-0.074***	(0.029)	-0.067***	(0.018)
Household	Partner	0.002	(0.031)	0.037	(0.040)
	NZ born	-0.057**	(0.026)	-0.015	(0.020)
	Number of people >=18 years	0.003	(0.008)	-0.011	(0.011)
	Number of people <18 years	-0.069***	(0.010)	-0.070***	(0.009)
Mobility	Numbers of residential moves	-0.018***	(0.006)	-0.007	(0.005)
	Rural location	0.009	(0.032)	-0.045	(0.029)
	Local healthcare	0.032	(0.020)	0.039**	(0.018)
	Drove car	-0.025	(0.024)	0.018	(0.026)
Other social aspects	Discriminated against	-0.001	(0.020)	-0.018	(0.020)
	Discouraged to immunise	-0.135***	(0.026)	-0.158***	(0.023)
	Encouraged to immunise	0.011	(0.019)	0.023	(0.018)
	Childcare services	0.045*	(0.028)	0.050**	(0.024)
	Observations	2453		2931	

Notes: SM = Sample mean. ***, **, * denote the coefficients are significantly different from zero at the 1%, 5%, and 10% level respectively. The ethnicity information is derived from self-prioritised ethnicity

Table A3 - Definitions of ethnicity variables and covariates from the survey at 9 months

	Variable	Definition	Mean
Ethnicity	NZ European	Binary indicator for NZ European in self-prioritised ethnicity	0.588
	Māori	Binary indicator for Māori in self-prioritised ethnicity	0.123
	Pacific peoples	Binary indicator for Pacific peoples in self-prioritised ethnicity	0.118
	Asian	Binary indicator for Asian in self-prioritised ethnicity	0.137
Mother & child	Girl	Binary indicator for whether child is a girl	0.488
	Birthweight (grams)	Child's birthweight (in grams)	3497.847
	First child	Binary indicator for whether child is the first born	0.413
	Child health/developmental problem	Binary indicator for whether child has a health/developmental problem	0.099
	Mother's age	Mother's age (in years)	31.546
	Mother's disability	Binary indicator for whether mother has a long-term disability that has lasted 6 months or more	0.042
	Smokes regularly	Binary indicator for whether mother smokes at least one cigarette per day	0.121
Socio-economic	Employment	Binary indicator of mother's employment (= 1 if employed in a job for wages and salaries; 0 otherwise)	0.404
	Post-graduation	Binary indicator for whether mother has a post-graduate qualification (e.g. Honours, Masters, Doctorate)	0.181
	Household income <NZ$ 50K	Binary indicator for household income less than NZ$ 50,000	0.287
	Household income >=NZ$ 50K & <=100K	Binary indicator for household income between NZ$ 50,000 and NZ$ 100,000	0.449
Household	Partner	Binary indicator for whether mother currently has a partner	0.936
	NZ born	Binary indicator derived from mother's country of birth (equals 1 if NZ; 0 otherwise)	0.668
	Number of people >= 18 years	Number of people aged 18 years or over residing in the same household as mother	1.440
	Number of people < 18 years	Number of people aged under 18 years residing in the same household as mother	2.072
Mobility	Numbers of residential moves	Number of times mother moved in the past 5 years	2.360
	Rural location	Binary indicator for whether mother lives in a rural area	0.083
	Local healthcare	Binary indicator for whether most of household's healthcare visits are in local areas	0.744
	Self-driving	Binary indicator for mother's main personal transport (equals 1 if drove private/company car; 0 otherwise)	0.853
Other social aspects	Discriminated against	Binary indicator for whether mother was a victim in the past of ethnically motivated unfair treatment (physical, verbal, and/or by a health professional)	0.220
	Discouraged to immunise	Binary indicator for whether during pregnancy mother received information that discouraged her to immunise child	0.150
	Encouraged to immunise	Binary indicator for whether during pregnancy mother received information that encouraged her to immunise child	0.384
	Childcare services	Binary indicator for whether child goes to any childcare services	0.145
	Observations		5341

Table A4 - Definitions of ethnicity variables and covariates from the survey at age 2

	Variable	Definition	Mean
Ethnicity	NZ European	Binary indicator for NZ European in self-prioritised ethnicity	0.585
	Māori	Binary indicator for Māori in self-prioritised ethnicity	0.127
	Pacific peoples	Binary indicator for Pacific peoples in self-prioritised ethnicity	0.121
	Asian	Binary indicator for Asian in self-prioritised ethnicity	0.134
Mother & child	Girl	Binary indicator for whether child is a girl	0.485
	Birthweight (grams)	Child's birthweight (in grams)	3492.868
	First child	Binary indicator for whether child is the first born	0.418
	Child health/developmental problem	Binary indicator for whether child has a health/developmental problem	0.077
	Mother's age	Mother's age (in years)	32.678
	Mother's disability	Binary indicator for whether mother has a long-term disability that has lasted 6 months or more	0.041
	Smokes regularly	Binary indicator for whether mother smokes at least one cigarette per day	0.123
Socio-economic	Employment	Binary indicator of mother's employment (equal 1 if employed in a job for wages and salaries; 0 otherwise)	0.555
	Post-graduation	Binary indicator for whether mother has a post-graduate qualification (e.g. Honours, Masters, Doctorate)	0.174
	Household income <NZ$ 50K	Binary indicator for household income less than NZ$ 50,000	0.276
	Household income >=NZ$ 50K & <=100K	Binary indicator for household income between NZ$ 50,000 and NZ$ 100,000	0.384
Household	Partner	Binary indicator for whether mother currently has a partner	0.914
	NZ born	Binary indicator derived from mother's country of birth (equals 1 if NZ; 0 otherwise)	0.668
	Number of siblings	Number of siblings	1.125
Mobility	Numbers of residential moves	Number of times mother moved since the last survey (at 9 months)	0.362
	Rural location	Binary indicator for whether mother lives in a rural area	0.084
	Self-driving	Binary indicator for mother's main personal transport (equals 1 if drove private/company car; 0 otherwise)	0.908
Other social aspects	Discriminated against	Binary indicator for whether mother was a victim in the past of ethnically motivated unfair treatment (physical, verbal, and/or by a health professional)	0.093
	Discouraged to immunise	Binary indicator for whether during pregnancy mother received information that discouraged her to immunise child	0.133
	Encouraged to immunise	Binary indicator for whether during pregnancy mother received information that encouraged her to immunise child	0.344
	Childcare services	Binary indicator for whether child goes to any childcare services	0.370
	Observations		5475

Table A5 - Definitions of ethnicity variables and covariates from the survey at age 4

	Variable	Definition	Mean
Ethnicity	NZ European	Binary indicator for NZ European in self-prioritised ethnicity	0.642
	Māori	Binary indicator for Māori in self-prioritised ethnicity	0.116
	Pacific peoples	Binary indicator for Pacific peoples in self-prioritised ethnicity	0.087
	Asian	Binary indicator for Asian in self-prioritised ethnicity	0.122
Mother & child	Girl	Binary indicator for whether child is a girl	0.489
	Birthweight (grams)	Child's birthweight (in grams)	3496.193
	First child	Binary indicator for whether child is the first born	0.427
	Child health concern	Binary indicator for whether there is general health concern for the child (e.g. vision, speech, behaviour, mobility etc.)	0.373
	Common illness	Binary indicator for whether child has had at least one common illness (e.g. wheezing, coughing, ear infections etc.)	0.748
	Mother's age	Mother's age (in years)	35.475
	Mother's disability	Binary indicator for whether mother has a long-term disability that has lasted 6 months or more	0.043
	Smokes regularly	Binary indicator for whether mother smokes at least one cigarette per day	0.109
Socio-economic	Employment	Binary indicator of mother's employment (equals 1 if employed in a job for wages and salaries; 0 otherwise)	0.520
	Post-graduation	Binary indicator for whether mother has a post-graduate qualification (e.g. Honours, Masters, Doctorate)	0.181
	Household income <NZ$ 50K	Binary indicator for household income less than NZ$ 50,000	0.648
	Household income >=NZ$ 50K & <=100K	Binary indicator for household income between NZ$ 50,000 and NZ$ 100,000	0.300
House hold	Partner	Binary indicator for whether mother currently has a partner	0.910
	NZ born	Binary indicator derived from mother's country of birth (equals 1 if NZ; 0 otherwise)	0.694
	Number of siblings	Number of siblings	1.678
Mobility	Numbers of residential moves	Number of times mother moved since the last survey (at age 2)	0.731
	Rural location	Binary indicator for whether mother lives in a rural area	0.103
	Self-driving	Binary indicator for mother's main personal transport (equals 1 if drove private/company car; 0 otherwise)	0.909
	Internet access	Binary indicator for whether household has internet access from home	0.935
Other social aspects	Discriminated against	Binary indicator for whether mother was a victim in the past of ethnically motivated unfair treatment (physical, verbal, and/or by a health professional)	0.089
	Discouraged to immunise	Binary indicator for whether during pregnancy mother received information that discouraged her to immunise child	0.139
	Encouraged to immunise	Binary indicator for whether during pregnancy mother received information that encouraged her to immunise child	0.336
	Childcare services	Binary indicator for whether child goes to any childcare services	0.942
	Observations		4832

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