Abstract:

Background:

Infectious disease (ID) hospitalisation rates are increasing in New Zealand (NZ), especially in preschool children, and Māori and Pacific people. We aimed to identify risk factors for ID hospitalisation in infancy within a birth cohort of NZ children, and to identify differences in risk factors between ethnic groups.

Methods:

We investigated an established cohort of 6846 NZ children, born in 2009-10, with linkage to a national dataset of hospitalisations. We used multivariable logistic regression to obtain odds ratios (OR) for factors associated with ID hospitalisation in the first year of life, firstly for all children, and then separately for Māori or Pacific children.

Results:

In the whole cohort, factors associated with ID hospitalisation were Māori (OR=1.49, 95%CI 1.17-1.89) or Pacific (2.51, 2.00-3.15) vs. European maternal ethnicity, male gender (1.32, 1.13-1.55), low birthweight (1.94, 1.39-2.66), exclusive breastfeeding for <4 months (1.22, 1.04-1.43), maternal experience of healthcare racism (1.60, 1.19-2.12), household deprivation (most vs. least deprived quintile of households [1.50, 1.12-2.02]), day-care attendance (1.43, 1.12-1.81), and maternal smoking (1.55, 1.26-1.91).

Factors associated with ID hospitalisation for Māori infants were: high household deprivation (2.16, 1.06-5.02) and maternal smoking (1.48, 1.02-2.14); and for Pacific infants: delayed immunization (1.72, 1.23-2.38), maternal experience of healthcare racism (2.20, 1.29-3.70), and maternal smoking (1.59, 1.10-2.29).

Conclusions:

Māori and Pacific children in NZ experience a high burden of ID hospitalisation. Some risk factors, for example maternal smoking, are shared while others are ethnic-specific. Interventions aimed at preventing ID hospitalisations should address both shared and ethnic-specific factors.

Key Words:

Infection; Infant; Māori; Pacific Islanders; Ethnic disparity

Introduction

Contemporary data show that the "epidemiological transition" of developed nations away from high rates of infectious disease (ID) has been incomplete.[1] Over recent decades childhood ID hospitalisation rates have increased in the United Kingdom, the United States (US), and New Zealand (NZ).[2-8] Recent data from NZ show that IDs remain the single largest cause of hospital admission.[6] Globally, IDs remain the most frequent cause of hospitalisation and death during childhood.[9-11]

Numerous risk factors for ID have been identified with male gender, lower birth weight, lower maternal education, parental unemployment, and poverty being among the most consistently identified.[7, 10, 12-16] The relationship of ethnicity to the risk of ID hospitalisation and the potential mechanisms by which ethnicity may increase the risk of ID hospitalisation have not been as thoroughly investigated. Several studies describing ethnic disparities in ID burden have suggested that ethnicity is associated independently of other demographic factors.[6, 8, 9, 17, 18] In NZ, ID burden varies several-fold by ethnicity. Ethnic groups in NZ include the indigenous Māori, and the descendants of migrants from Europe, the Pacific, Asia and elsewhere. Recent increases in ID hospitalisation rates have been more rapid in the Māori and Pacific ethnic groups.[6]

Our aim was to identify, within a diverse study sample, the factors associated with ID hospitalisation during infancy, and to determine factors independently associated with the risk of ID hospitalisation within ethnic groups with higher ID hospitalisation rates.

Materials and Methods

Study design

This study was completed within the *Growing Up in New Zealand* (www.growingup.co.nz) birth cohort of 6853 children. Mothers were enrolled in the antenatal period after providing written informed consent. Recruitment was via self-referral, referral from maternity carers or antenatal clinics, and direct face-to-face invitation.[19,20] The cohort represents 11% of the national birth cohort for the enrolment period and is broadly generalizable to the

contemporary national birth cohort in terms of ethnicity and socioeconomic status.[21] Ethical approval was obtained from the Ministry of Health Northern Y Regional Ethics Committee.

Data collection and linkage

Data were obtained from interviews with the child's main caregivers and linkage to national administrative datasets. Caregivers were interviewed antenatally, and when their child was approximately nine months old. The 9-month interview was completed for 6470 (94%) of the 6853 cohort children. Information obtained described child demographics, breastfeeding, healthcare received, and maternal, household, and environmental characteristics.

Consent for linkage was obtained for 6682/6853 (98%). Linkage was established for 6674/6682 (97%) with three administrative datasets: maternity hospital records; immunization records contained in the National Immunization Register (NIR),[22, 23] and the national collection of hospitalisation data contained in the National Minimum Dataset (NMDS).

In NZ, almost all acute paediatric hospitalisations are to public hospitals and are free to NZ citizens and permanent residents. The NMDS records coded diagnostic information, provided for all public and most private hospital admissions, using the Australian Modification of the International Statistical Classification of Diseases (ICD-10-AM).[24]

Definitions

An infant was defined as not having a consistent family doctor if their mother stated that their care was usually provided by multiple family medicine practices, by after-hours accident and medical centres, or by a hospital emergency department. We defined immunization timeliness as receipt of all scheduled vaccines within 30 days of their due date.[25, 26]

More than one ethnicity was listed for 41% of the cohort children. Ethnicity was therefore defined using maternal self-identified main ethnicity. Ethnicity was categorised as Māori, Pacific, Asian, Middle Eastern / Latin American / African (MELAA), and a combined European/Other reference group.

Household deprivation was measured using the 2006 NZ Index of Deprivation (NZDep2006), a well-validated measure of socioeconomic deprivation based on geographic area, derived

from a median of 90 people per area block, that divides the population into deprivation deciles and is assigned to households based on their address,.[27] Crowding was measured as a ratio of household occupants to bedrooms, with a ratio of ≥2 defining a higher level of crowding. Healthcare racism was defined as maternal experience of bias, on the basis of ethnicity, from healthcare professionals at any time prior to the antenatal interview.

An infant ID hospital admission was defined be a primary discharge diagnostic code (indicating the primary cause for that hospitalisation) for an ID. Hospitalisations after 365 days of age were censored. ID hospitalisations were categorized into five groups: respiratory (both upper and lower), gastrointestinal (including intra-abdominal infections); urinary tract; congenital and perinatal; and other ID hospitalisations.

Study power

The cohort was designed to have sufficient power to undertake analyses across the whole cohort and within ethnic subgroups. An ethnic subgroup sample of 1000 children provides 80% power at the 0.05 level of significance to detect a relative risk of ID hospitalisation of 2.1, if 10% of the unexposed population is hospitalized and at least 10% of the population is exposed to the risk factor of interest.

Statistical analyses

Statistical analyses were performed using SAS® version 9.4 (SAS Institute, Cary, NC, USA). Descriptive statistics were calculated. Unadjusted associations were examined using the chi-squared or Fisher's exact tests. The independence of associations was examined using multivariable logistic regression. Results from the regression analyses were presented using odds ratios (OR) and 95% confidence intervals (CI). P-values of less than 0.05 were regarded as significant.

Variables were included in the multivariable analyses based on the magnitude and significance ($p \leq 0.15$) of the unadjusted association, and completeness of data. Household income was not reported by 869 mothers and was more likely to be missing for households in deprived areas. Therefore NZDep2006 rather than income was included in multivariable analyses. NZDep2006 is derived from census measures including income, education, and

crowding, so these variables were not included to avoid covariance.[28] For variables with obvious covariance the variable with the strongest unadjusted association was included. Three multivariable models were constructed for the whole cohort. Model 1 included maternal ethnicity and NZDep2006. Model 2 added variables describing child demographics and breastfeeding. Model 3 added variables describing healthcare access, maternal demographics and household characteristics. Variables were retained in the model if their addition reduced the Akaike Information Criterion.

Unadjusted and multivariable analyses were performed within the Māori and Pacific ethnic subgroups. A single multivariable model was constructed for each separately, considering all variables with an unadjusted association p-value of 0.15 or less in that ethnic subgroup. For the Pacific subgroup analysis, NZDep2006 deciles 8-10 were compared to deciles 1-7 because 81% of Pacific mothers lived in households in the NZDep2006 8-10 category, while for the Māori subgroup analysis three levels of deprivation were used.

Results

Complete data from the antenatal and nine-month interviews, and the linked perinatal and NMDS were available for 5960/6853 (87%) children (Figure 1). The self-identified main ethnicities of the mothers of the cohort children were Māori (13%), Pacific (14%), Asian (15%), MELAA (2%), and European or other (56%).

There were 1042 ID hospitalisations experienced by 764 children in their first year of life, with 170/764 (22%) of these children having more than one ID hospitalisation. Of the 1042 ID hospitalisations, 653/1042 (63%) were for respiratory, 150/1042 (14%) for gastrointestinal, 30/1042 (3%) for skin and soft tissue, 45/1042 (4%) for urinary tract, 55/1042 (5%) for congenital and perinatal, and 109/1042 (10%) for 'other' infections.

Most ID hospitalisations were of short duration. Of the first ID hospitalisation for the 764 children who had one or more ID hospitalisations, 227 (30%) had a length of stay of <1 day and 198 (26%) of 1 day's duration.

In comparison with children whose mothers were of European/other ethnicities, the children whose mothers' were of Māori (RR=2.01) or Pacific (RR=2.72) ethnicity were at increased

risk of ID hospitalisation (Table 1). Māori or Pacific maternal ethnicity was also associated specifically with an increased risk of hospitalisation for respiratory, gastrointestinal, and skin and soft tissue infections (Table 1).

In unadjusted analyses, the risk of ID hospitalisation was also associated with child demographics (male gender, low birthweight, having older siblings), breastfeeding, healthcare experience (delayed immunizations, maternal experience of racism), and household and environmental characteristics (lower income, greater deprivation or crowding, cigarette smoke exposure either during pregnancy or infancy, lower child bathing frequency, urban residence, and day-care attendance) (Table 2).[29]

In the final multivariable model (model 3), independent associations with an increased risk of ID hospitalisation were identified for male gender (OR=1.32), low birthweight (OR=1.94), exclusive breastfeeding for <4 months (OR=1.22), maternal experience of healthcare racism (OR=1.60), maternal Māori (OR=1.49) or Pacific (OR=2.51) ethnicity compared with European ethnicity, socioeconomic deprivation (NZDep2006 deciles 7-8: OR=1.71 and deciles 9-10: OR=1.50), day-care attendance (OR=1.43), and exposure to maternal smoking at 9 months (OR=1.55) (Table 3).

A strong relationship was evident between Māori or Pacific ethnicity and a more deprived NZDep2006 decile ($p<0.01$). Infants of mothers of Māori or Pacific ethnicity were also less likely to have received their routine childhood immunizations in a timely fashion. The proportion of infants of mothers of Māori or Pacific ethnicity with delayed immunizations was 42% and 33% respectively, compared to 14%, 17% and 27% respectively for the infants of mothers of Asian, MELAA, or European/other ethnicity ($p<0.001$).

In unadjusted analyses, the factors associated with ID hospitalisation for infants of mothers of Māori ethnicity were found to differ from those for infants of mothers of Pacific ethnicity (Table 4). In the multivariable analyses within the maternal Māori and Pacific ethnic groups (Table 5), the variables independently associated with ID hospitalisation for the infants of mothers of Māori ethnicity were greater deprivation (NZDep2006 deciles 8-10, OR=2.16) and exposure to maternal cigarette smoking at age 9 months (OR=1.48). For the infants of mothers of Pacific ethnicity independent associations were identified with having delayed immunizations (OR=1.72), maternal experience of healthcare racism (OR=2.20), and exposure to maternal cigarette smoking at age 9 months (OR=1.59).

Discussion

In this nationally representative contemporary cohort, the infants of mothers of Māori or Pacific ethnicity experienced a larger burden of ID hospitalisations in the first year of life, with adjusted multivariable ORs for ID hospitalisation of 1.49 and 2.51 respectively. The excess of ID hospitalisations experienced by infants of Māori or Pacific mothers was only partly explained by exposure to poverty-related risk factors such as household deprivation. Furthermore, we showed that the factors associated with ID hospitalisation differed between infants of mothers of Māori compared with Pacific ethnicity.

Prior data from the USA, Australia and NZ also show ethnic disparities in ID burden.[6-9, 15, 17, 18] In NZ, the ID hospitalisation rates for Māori and Pacific people, and the excess in the ID burden of people of these ethnicities relative to Europeans, have increased over the past 20 years.[6] In Australia, both hospitalisation rates and in-hospital deaths from ID are greater for Aboriginal children.[15, 17] Similar disparities in ID hospitalisation rates have been noted in non-white children in the USA, and in Bedouin compared with Jewish children in Israel.[9, 10, 18]

Ethnic minority groups are often disproportionately exposed to poverty-related factors and this study showed that the children of Māori and Pacific mothers were indeed more likely to live in areas of high socioeconomic deprivation. The excess risk of ID hospitalisation was not fully accounted for by these factors though. In the multivariable analysis, maternal ethnicity remained an important predictor of ID hospitalisation even when other social determinants of health were accounted for. It was observed that in the highest stratum of household income (>NZ$ 100,000), the rate of ID hospitalisation for infants of Māori mothers (9%) was similar to the cohort as a whole (8%), in contrast to the ID hospitalisation rate for infants of Pacific mothers which remained high across all income strata. This observation suggests the possibility of an interaction between ethnicity and income. The use of interaction terms will be considered in future research within the cohort.

The child demographic factors associated with an increased risk of ID hospitalisation in this study, male gender and low birthweight, have been identified previously.[10, 16] Low birthweight is associated with adverse health consequences throughout childhood and later life and, to a limited extent, might be amenable to intervention.[30] Rates of low birthweight are increasing in some countries suggesting that this risk factor may become more important.[31, 32]

Breastfeeding has an established role in the prevention of infection in infancy. There is debate over the recommended duration of exclusive breastfeeding in the developed world, and over whether exclusive or total breastfeeding duration is more important.[33-35] We identified that shorter durations of both exclusive and total breastfeeding were associated with an increased risk of ID hospitalisation. While maintaining breastfeeding can be challenging, our findings support the development of policy that enables mothers to breastfeed exclusively for at least 4 months.

This study did not identify a relationship between consistent primary healthcare and ID hospitalisation. Previous research has suggested that children with more primary healthcare attendances are less likely to present to hospital, and that reduced primary care access is an important cause of excess hospitalisation in indigenous children.[15, 36] We identified maternal experience of racism from a healthcare professional as an independent predictor of infant ID hospitalisation. Actions to combat racism within the healthcare setting and to re-engage mothers who have had these experiences would appear to be priority areas for intervention to reduce disparities in ID hospitalisations in infancy.

Poverty and related factors (maternal education, employment status, socioeconomic deprivation, and household crowding) are amongst the most consistently identified risk factors for ID hospitalisation in infants.[10, 36] Some studies have identified counter-intuitive effects on hospitalisation rates due to significant barriers to hospitalisation for the most deprived children.[36] While NZ's healthcare system provides free care to children, it is possible for adult family members to accumulate debt with their family medicine practice. [37] This is an important pathway by which poverty may lead more directly to hospitalisation than in countries where all primary healthcare is free.

Household crowding has been shown to contribute to epidemics of ID in NZ, for example of pertussis and meningococcus.[38, 39] While addressing crowding directly is important, strategies aimed at reducing household transmission, such as immunization, may minimize some of the harmful effects of household crowding. It is concerning that we identified an association between Māori or Pacific ethnicity and delayed or incomplete immunization. Prioritising the timely immunization of children at greatest risk of vaccine preventable disease remains a public health priority.

Strengths of our study included the large cohort size, ethnic diversity, low attrition rates, and the capacity to link to a national dataset of all hospitalisations. The study also had some

limitations. Although previous estimates of ICD-10-AM coding accuracy in NZ suggest that it is correct to the third digit in >85% of cases, it is likely that a small proportion of children will have been assigned an incorrect diagnostic code or an incorrect ordering of codes.[41] We only analysed the first diagnostic code, which has the potential to underestimate the true frequency of ID hospitalisation. This was intentional so as to avoid including nosocomial infections. A significant proportion of mothers declined or were unable to answer questions regarding income (15%) or employment at 9 months (17%) which necessitated the use of the census-derived NZ Index of Deprivation in our analyses.

In summary, NZ infants of mothers of Māori and Pacific ethnicity experience an excess of ID hospitalisations in the first year of life. We have identified several modifiable risk factors for ID hospitalisation in NZ during infancy, including shorter duration of breastfeeding, maternal experience of racism in healthcare, household socioeconomic deprivation and crowding, maternal smoking, and day-care attendance. Risk factors differed between infants of mother of Māori versus Pacific ethnicity, suggesting that specific, culturally focused interventions are necessary. Health system interventions to reduce smoking, encourage breastfeeding, and to address perceived racism are likely to benefit all infants. Social interventions to reduce socioeconomic deprivation and household crowding are also necessary to reduce the rate of and disparities in infant ID hospitalisation.

Acknowledgements:

Dr Hobbs is supported by the Auckland Medical Research Foundation Douglas Goodfellow Medical Research Fellowship. *Growing Up in New Zealand* has been funded by the New Zealand Ministries of Social Development, Health, Education, Justice and Pacific Island Affairs; the former Ministry of Science Innovation and the former Department of Labour (now both part of the Ministry of Business, Innovation and Employment); the former Ministry of Women's Affairs (now the Ministry for Women); the Department of Corrections; the Families Commission (now known as the Social Policy Evaluation and Research Unit); Te Puni Kokiri; New Zealand Police; Sport New Zealand; the Housing New Zealand Corporation; and the former Mental Health Commission, The University of Auckland and

Auckland UniServices Limited. Other support for the study has been provided by the NZ Health Research Council, Statistics New Zealand, the Office of the Children's Commissioner and the Office of Ethnic Affairs. The study has been designed and conducted by the Growing Up in New Zealand study team, led by the University of Auckland. The authors acknowledge the contributions of the original study investigators: Susan M.B. Morton, Polly E. Atatoa Carr, Cameron C. Grant, Arier C. Lee, Dinusha K. Bandara, Jatender Mohal, Jennifer M. Kinloch, Johanna M. Schmidt, Mary R. Hedges, Vivienne C. Ivory, Te Kani R. Kingi, Renee Liang, Lana M. Perese, Elizabeth Peterson, Jan E. Pryor, Elaine Reese, Elizabeth M. Robinson, Karen E. Waldie, Clare R. Wall. The views reported in this paper are those of the authors and do not necessarily represent the views of the Growing Up in New Zealand Investigators.

References

1. Mackenbach JP. The epidemiologic transition theory. Journal of epidemiology and community health. 1994;48(4):329-31.

2. Gill PJ, Goldacre MJ, Mant D, *et al*. Increase in emergency admissions to hospital for children aged under 15 in England, 1999–2010: national database analysis. Archives of Disease in Childhood. 2013;98(5):328-34.

3. Holman RC, Curns AT, Cheek JE, Singleton RJ, Anderson LJ, Pinner RW. Infectious disease hospitalisations among American Indian and Alaska native infants. Pediatrics. 2003;111(2):E176-82.

4. Holman RC, Folkema AM, Singleton RJ, *et al*. Disparities in Infectious Disease Hospitalisations for American Indian/Alaska Native People. Public Health Reports. 2011;126(4):508-21.

5. Armstrong GL, Conn LA, Pinner RW. Trends in infectious disease mortality in the United States during the 20th century. JAMA. 1999;281(1):61-6.

6. Baker MG, Barnard LT, Kvalsvig A, *et al*. Increasing incidence of serious infectious diseases and inequalities in New Zealand: a national epidemiological study. The Lancet. 2012;379(9821):1112-9.

7. Simonsen L, Conn LA, Pinner RW, Teutsch S. Trends in infectious disease hospitalisations in the United States, 1980-1994. Archives of Internal Medicine. 1998;158(17):1923-8.

8. Yorita-Christensen KL, Holman RC, Steiner CA, Sejvar JJ, Stoll BJ, Schonberger LB. Infectious Disease Hospitalisations in the United States. Clinical Infectious Diseases. 2009;49(7):1025-35.

9. Read JS, Troendle JF, Klebanoff MA. Infectious disease mortality among infants in the United States, 1983 through 1987. American Journal of Public Health. 1997;87(2):192-8.

10. Yorita KL, Holman RC, Sejvar JJ, Steiner CA, Schonberger LB. Infectious Disease Hospitalisations Among Infants in the United States. Pediatrics. 2008;121(2):244-52.

11. Liu L, Johnson HL, Cousens S, *et al*. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. The Lancet.379(9832):2151-61.

12. Biering-Sørensen S, Søndergaard G, Vitting Andersen K, Andersen A-MN, Mortensen LH. Time trends in socio-economic factors and risk of hospitalisation with infectious diseases in pre-school children 1985–2004: a Danish register-based study. Paediatric and Perinatal Epidemiology. 2012;26(3):226-35.

13. Fosarelli PD, Deangelis C, Winkelstein J, Mellits ED. Infectious illnesses in the first two years of life. Paediatric Infectious Disease. 1985;4(2):153-9.

14. Hepworth S, Law G, Lawlor D, McKinney P. Early life patterns of common infection: a latent class analysis. Eur J Epidemiol. 2010;25(12):875-83.

15. Ou L, Chen J, Hillman K, Eastwood J. The comparison of health status and health services utilisation between Indigenous and non-Indigenous infants in Australia. Australian and New Zealand Journal of Public Health. 2010;34(1):50-6.

16. Thrane N, Søndergaard C, Schønheyder H, Sørensen H. Socioeconomic factors and risk of hospitalisation with infectious diseases in 0- to 2-year-old Danish children. Eur J Epidemiol. 2005;20(5):467-74.

17. Carville KS, Lehmann D, Hall G, *et al*. Infection Is the Major Component of the Disease Burden in Aboriginal and Non-Aboriginal Australian Children: A Population-Based Study. The Pediatric Infectious Disease Journal. 2007;26(3):210-6 10.1097/01.inf.0000254148.09831.7f.

18. Levy A, Fraser D, Vardi H, Dagan R. Hospitalisations for infectious diseases in Jewish and Bedouin children in southern Israel. Eur J Epidemiol. 1998;14(2):179-86.

19. Morton SMB, Atatoa Carr PE, Grant CC, *et al.* Cohort Profile: Growing Up in New Zealand. International Journal of Epidemiology. 2013;42(1):65-75.

20. Morton SMB, Grant CC, Atatoa Carr PE, *et al*. How do you Recruit and Retain a Prebirth Cohort? Lessons Learnt from Growing Up in New Zealand. Evaluation & the Health Professions. 2012;00(0):1-23.

21. Morton S, Ramke J, Kinloch J, *et al*. Growing Up in New Zealand cohort alignment with all New Zealand births. Australian and New Zealand Journal of Public Health. 2015;39(1):82-7.

22. Ministry of Health. National Immunisation Register [Internet]. Wellington: Ministry of Health; 2012.

23. Ministry of Health. Immunisation Handbook 2011. Wellington: Ministry of Health; 2011.

24. World Health Organisation. ICD-10 Version:2015 [Internet]. Geneva: World Health Organisation; 2015.

25. Luman ET, Barker LE, Shaw KM, McCauley MM, Buehler JW, Pickering LK. Timeliness of childhood vaccinations in the United States: days undervaccinated and number of vaccines delayed. JAMA. 2005;293(10):1204-11.

26. Hull BP, McIntyre PB. Timeliness of childhood immunisation in Australia. Vaccine. 2006;24(20):4403-8.

27. Salmond C, Crampton P, Atkinson J. NZDep2006 Index of Deprivation. Wellington: Department of Public Health, University of Otago; 2007.

28. White P, Gunston J, Salmond C, Atkinson J, Crampton P. Atlas of Socioeconomic Deprivation in New Zealand NZDep2006 [Internet]. Wellington: Ministry of Health; 2008.

29. Perry B. Household incomes in New Zealand: Trends in indicators of inequality and hardship 1982 to 2010 [Internet]. Wellington: Ministry of Social Development; 2011. Available from: www.msd.govt.nz/about-msd-and-our-work/publications-resources/monitoring/index.html

30. Lu MC, Tache V, Alexander GR, Kotelchuck M, Halfon N. Preventing low birth weight: is prenatal care the answer? The Journal of Mater. 2003;13(6):362-80.

31. Takimoto H, Yokoyama T, Yoshiike N, Fukuoka H. Increase in low-birth-weight infants in Japan and associated risk factors, 1980–2000. Journal of Obstetrics and Gynaecology Research. 2005;31(4):314-22.

32. Martin JA, Hamilton BE, Osterman MJK, Curtin SC, Mathews TJ. Births: Final Data for 2013, National Vital Statistics Reports [Internet]. Hyattsville, MD: National Center for Health Statistics; 2015.

33. Section on Breastfeeding. Breastfeeding and the Use of Human Milk. Pediatrics. 2012;129(3):e827-e41.

34. Fewtrell MS, Morgan JB, Duggan C, *et al*. Optimal duration of exclusive breastfeeding: what is the evidence to support current recommendations? The American journal of clinical nutrition. 2007;85(2):635S-8S.

35. Kramer MS, Kakuma R. Optimal duration of exclusive breastfeeding. The Cochrane database of systematic reviews. 2012;8:CD003517.

36. Nikièma B, Zunzunegui M, Séguin L, Gauvin L, Potvin L. Poverty and Cumulative Hospitalisation in Infancy and Early Childhood in the Quebec Birth Cohort: A Puzzling Pattern of Association. Matern Child Health J. 2008;12(4):534-44.

37. Grant CC, Petousis-Harris H, Turner N, et al. Primary care practice and health professional determinants of immunisation coverage. Journal of Paediatrics & Child Health 2011; 47(8): 541-9.

38. Baker M, McNicholas A, Garrett N, *et al*. Household crowding a major risk factor for epidemic meningococcal disease in Auckland children. Pediatric Infectious Disease Journal. 2000;19(10):983-90.

39. Somerville RL, Grant CC, Scragg RK, Thomas MG. Hospitalisations due to pertussis in New Zealand in the pre-immunisation and mass immunisation eras. Journal of Paediatrics and Child Health. 2007;43(3):147-53.

40. Emery DP, Milne T, Gilchrist CA, *et al*. The impact of primary care on emergency department presentation and hospital admission with pneumonia: a case-control study of preschool-aged children. NPJ primary care respiratory medicine. 2015;25:14113.

41. Davie G, Langley J, Samaranayaka A, Wetherspoon ME. Accuracy of injury coding under ICD-10-AM for New Zealand public hospital discharges. Injury prevention : journal of the International Society for Child and Adolescent Injury Prevention. 2008;14(5):319-23.

TABLE 1. Infectious disease (ID) hospitalisations during infancy by maternal ethnicity and type of infection

	All	Maternal self-prioritised ethnic group					
	children	**European**	**Māori**	**Pacific**	**Asian**	**MELAA**	**p-value†**
n	5960	3339	777	841	884	119	
Any ID hospitalisation, n (%)	764 (13)	312 (9)	146 (19)	214 (25)	83 (9)	‡	<0.001
RR (95% CI)	-	1.00 (ref)	2.01 (1.68-2.41)	2.72 (2.33-3.19)	1.00 (0.80-1.27)	0.81 (0.43-1.53)	
ID hospitalisation type							
Respiratory, n (%)	459 (8)	167 (5)	105 (14)	143 (17)	39 (4)	‡	<0.001
RR (95% CI)	-	1.00 (ref)	2.70 (2.14-3.41)	3.40 (2.76-4.19)	0.88 (0.63-1.24)	0.84 (0.35-2.01)	
Gastrointestinal, n (%)	140 (2)	61 (2)	28 (4)	38 (5)	12 (1)	‡	<0.001
RR (95% CI)	-	1.00 (ref)	1.97 (1.27-3.06)	2.47 (1.66-3.68)	0.74 (0.40-1.37)	0.46 (0.06-3.29)	
Skin / soft tissue, n (%)	26 (<1)	‡	‡	‡	0 (0)	‡	<0.001
RR (95% CI)	-	1.00 (ref)	4.83 (1.87-12.49)	3.97 (1.49-10.55)	-	3.51 (0.44-27.82)	
Urinary, n (%)	44 (<1)	24 (<1)	‡	10 (1)	‡	0	0.433
RR (95% CI)	-	1.00 (ref)	0.72 (0.25-2.06)	1.65 (0.79-3.45)	0.94 (0.39-2.30)	-	
Congenital, n (%)	55 (<1)	27 (<1)	‡	12 (1)	‡	0	0.404
RR (95% CI)	-	1.00 (ref)	1.11 (0.49-2.55)	1.76 (0.90-3.47)	1.26 (0.59-2.67)	-	

Other, n (%)		107 (2)	48 (1)	12 (2)	25 (3)	20 (2)	2 (2)	0.034
	RR (95% CI)	-	1.00 (ref)	1.07 (0.57-2.01)	2.07 (1.28-3.33)	1.57 (0.94-2.64)	1.17 (0.29-4.75)	

RR=rate ratio; CI=confidence interval.

† χ^2 p-value for difference between ethnic groups.

‡ Cells containing less than 10 participants have had absolute numbers and percentages withheld to protect participant anonymity.

TABLE 2. Univariable logistic regression of hospitalisation for infection in the first year of life in relation to infant and maternal factors

	All children	**Children with one or more infectious disease hospitalisations during the first year of life**		
Variable	**n (%)**	**n (%)**	**OR (95% CI)**	**p-value**
		Child factors		
Male gender	3093 (52)	444 (14)	1.33 (1.14-1.56)	<0.001
Birthweight <2500 g	258 (4)	53 (21)	1.82 (1.33-2.50)	<0.001
Second or subsequent child	3417 (57)	480 (14)	1.30 (1.11-1.52)	0.001
Exclusive breastfeeding < 4 months†	2411 (40)	369 (15)	1.44 (1.24-1.68)	<0.001
Total breastfeeding < 9 months†	3180 (54)	447 (14)	1.28 (1.10-1.50)	0.002
		Healthcare		
Child attends multiple family medicine practices or no regular practice	380 (6)	53 (14)	1.11 (0.82-1.50)	0.476
Delayed or incomplete routine vaccinations, 9 months	1646 (28)	255 (15)	1.37 (1.17-1.61)	<0.001
Maternal prior experience of racism from health care professional	324 (5)	70 (22)	1.98 (1.50-2.62)	<0.001
		Socio-demographics		
Maternal ethnicity (self-prioritised)				
Māori	777 (13)	146 (19)	2.24 (1.81-2.78)	<0.001
Pacific	841 (14)	214 (25)	3.31 (2.73-4.02)	<0.001
Asian	884 (15)	83 (9)	1.01 (0.78-1.30)	0.967
MELAA	119 (2)	‡	0.79 (0.40-1.58)	0.512
European / Other	3339 (56)	312 (9)	Reference	Reference

Maternal education				
Primary	388 (7)	84 (22)	2.83 (2.14-3.75)	<0.001
Secondary	1402 (24)	217 (15)	1.88 (1.53-2.30)	<0.001
Diploma/trade	1832 (31)	248 (14)	1.61 (1.32-1.95)	<0.001
Degree	2318 (39)	206 (9)	Reference	Reference
Maternal unemployment, 9 months§	2722 (55)	399 (15)	1.22 (1.03-1.44)	0.020
"Poor" to "Fair" self-rated health	590 (10)	116 (20)	1.78 (1.43-2.22)	<0.001
Household income (NZ$)§				
<$30,000	551 (11)	115 (21)	2.94 (2.21-3.90)	<0.001
$30,001 - $50,000	927 (18)	152 (16)	2.18 (1.68-2.83)	<0.001
$50,001 - $70,000	1089 (21)	139 (13)	1.63 (1.25-2.12)	<0.001
$70,001 - $100,000	1177 (23)	119 (10)	1.25 (0.95-1.64)	0.104
>$100,001	1347 (26)	111 (8)	Reference	Reference
Deprivation (NZDep2006 deciles)				
1 – 2 (least deprived)	1005 (17)	80 (8)	Reference	Reference
3 – 4	1120 (19)	84 (8)	0.94 (0.68-1.29)	0.692
5 – 6	1033 (17)	107 (10)	1.34 (0.99-1.81)	0.062
7 – 8	1227 (21)	193 (16)	2.16 (1.64-2.84)	<0.001
9 – 10 (most deprived)	1565 (26)	297 (19)	2.71 (2.09-3.52)	<0.001
High crowding index, 9 months¶	1320 (22)	258 (20)	1.98 (1.68-2.34)	<0.001
Total household numbers >5, 9 months	783 (13)	182 (23)	2.39 (1.98-2.88)	<0.001
Maternal smoking in pregnancy•	1057 (18)	206 (19)	1.88 (1.58-2.25)	<0.001
Maternal smoking, 9 months	843 (14)	188 (22)	2.26 (1.88-2.72)	<0.001
Household smoking, 9 months	1750 (29)	317 (18)	1.86 (1.59-2.18)	<0.001
Bathing of child < daily, 9 months	1797 (30)	264 (15)	1.26 (1.07-1.48)	0.005

Resident in an urban region	5528 (92)	733 (13)	1.98 (1.36-2.87)	<0.001
Daycare attendance, 9 months	647 (11)	101 (16)	1.30 (1.03-1.63)	0.029

OR=odds ratio; CI=confidence interval; MELAA= Middle Eastern, Latin American and African; NZDep2006=New Zealand Index of Deprivation derived from the 2006 national census.

† Includes infants who were never breastfed.

‡ Cells containing less than 10 participants have had absolute numbers and percentages withheld to protect participant anonymity.

§ Data for income and maternal employment status at 9 months post-delivery were incomplete. Median household income in NZ in 2010 was NZ$75,700 (31).

¶ Defined as >2 persons per bedroom.

• Includes mothers who continued smoking throughout their pregnancy and those who smoked at the start of pregnancy and quit during pregnancy.

TABLE 3. Multivariable logistic regression of hospitalisation for infection in the first year of life in relation to infant and maternal factors

	Model 1 (n=5950)		Model 2 (n=5950)		Model 3 (n=5893)	
Variable	**AOR (95% CI)**	**p-value**	**AOR (95% CI)**	**p-value**	**AOR (95% CI)**	**p-value**
Child factors						
Male gender			1.33 (1.13-1.55)	0.001	1.32 (1.13-1.55)	0.001
Birthweight <2500 g			1.95 (1.40-2.68)	<0.001	1.94 (1.39-2.66)	<0.001
Second or subsequent child			1.20 (1.02-1.41)	0.027	1.16 (0.98-1.38)	0.079
Exclusive breastfeeding <4 months			1.31 (1.11-1.53)	0.001	1.22 (1.04-1.43)	0.016
Healthcare						
Delayed or incomplete routine vaccinations, 9 months					1.18 (0.99-1.40)	0.071
Maternal prior experience of racism from health care professional					1.60 (1.19-2.12)	0.001
Socio-demographics						
Maternal ethnicity (self-prioritised)						
Māori	1.84 (1.47-2.31)	<0.001	1.76 (1.40-2.22)	<0.001	1.49 (1.17-1.89)	0.001
Pacific	2.57 (2.06-3.20)	<0.001	2.55 (2.04-3.19)	<0.001	2.51 (2.00-3.15)	<0.001

Asian	0.90 (0.69-1.15)	0.400	0.88 (0.67-1.13)	0.317	0.96 (0.73-1.25)	0.751
MELAA	0.73 (0.34-1.38)	0.376	0.74 (0.35-1.41)	0.400	0.70 (0.31-1.38)	0.347
European / Other	Reference	Reference	Reference	Reference	Reference	Reference
Deprivation (NZDep2006 deciles)						
1 – 2 (least deprived)	Reference	Reference	Reference	Reference	Reference	Reference
3 – 4	0.90 (0.65-1.24)	0.519	0.91 (0.66-1.26)	0.580	0.86 (0.62-1.19)	0.356
5 – 6	1.23 (0.91-1.67)	0.189	1.23 (0.91-1.68)	0.181	1.19 (0.88-1.63)	0.262
7 – 8	1.75 (1.32-2.34)	<0.001	1.76 (1.33-2.36)	<0.001	1.71 (1.28-2.29)	<0.001
9 – 10 (most deprived)	1.68 (1.27-2.25)	<0.001	1.65 (1.24-2.21)	0.001	1.50 (1.12-2.02)	0.008
Maternal smoking, 9 months					1.55 (1.26-1.91)	<0.001
Daycare attendance, 9 months					1.43 (1.12-1.81)	0.003

AOR=adjusted odds ratio; CI=confidence interval; MELAA= Middle Eastern, Latin American and African; NZDep2006= New Zealand Index of Deprivation derived from the 2006 national census.

TABLE 4. Univariable logistic regression of hospitalisation with infection in the first year of life in relation to infant and maternal factors, for infants of Māori and Pacific mothers

	Infants of mothers of Māori ethnicity				Infants of mothers of Pacific ethnicity			
	Total	Infants with ID hospitalisation			Total	Infants with ID hospitalisation		
	N (%)	n (%)	OR (95% CI)	p-value	N (%)	n (%)	OR (95% CI)	p-value
	777 (100)	146 (19)	-	-	841 (100)	214 (26)	-	-
Child factors								
Birthweight <2500 g	36 (5)	†	1.47 (0.68-3.20)	0.380	22 (3)	†	2.07 (0.87-4.92)	0.133
Second or subsequent child	500 (64)	95 (19)	1.04 (0.71-1.52)	0.923	574 (68)	151 (26)	1.16 (0.82-1.62)	0.444
Male sex	414 (53)	82 (20)	1.15 (0.80-1.66)	0.462	443 (53)	122 (28)	1.26 (0.92-1.73)	0.154
Exclusive breastfeeding <4 months	387 (50)	76 (20)	1.12 (0.78-1.60)	0.582	362 (43)	107 (30)	1.46 (1.07-1.99)	0.020
Total breastfeeding <9 months	465 (60)	94 (20)	1.26 (0.86-1.83)	0.261	442 (53)	127 (29)	1.45 (1.06-1.99)	0.021
Healthcare								
Child attends multiple family medicine practices or no regular practice	53 (7)	10 (19)	1.01 (0.49-2.05)	1.000	61 (7)	15 (25)	0.95 (0.52-1.74)	1.000
Delayed or incomplete routine vaccinations, 9 months	324 (42)	57 (18)	0.87 (0.60-1.26)	0.515	278 (33)	91 (33)	1.74 (1.26-2.40)	0.001

Maternal prior experience of racism from health care provider	89 (12)	20 (23)	1.29 (0.76-2.20)	0.386	69 (8)	28 (41)	2.15 (1.29-3.57)	0.004
Socio-demographics								
Maternal highest completed education level secondary level or below	367 (47)	79 (22)	1.43 (0.99-2.05)	0.065	458 (55)	119 (26)	1.10 (0.80-1.50)	0.577
Maternal unemployment, 9m	461 (66)	94 (20)	1.41 (0.92-2.15)	0.123	500 (66)	132 (26)	1.09 (0.77-1.54)	0.664
Maternal "Poor" to "Fair" self-rated health	169 (22)	34 (20)	1.12 (0.73-1.71)	0.656	152 (18)	43 (28)	1.20 (0.81-1.77)	0.411
Household income (NZ$)								
<$30,000	147 (24)	39 (27)	3.61 (1.60-8.15)	0.002	121 (20)	38 (31)	1.47 (0.73-2.94)	0.282
$30,001 - $50,000	149 (24)	29 (20)	2.42 (1.05-5.55)	0.038	198 (32)	49 (25)	1.05 (0.54-2.04)	0.880
$50,001 - $70,000	131 (21)	23 (18)	2.13 (0.91-5.01)	0.083	150 (25)	37 (25)	1.05 (0.53-2.09)	0.894
$70,001 - $100,000	101 (16)	14 (14)	1.61 (0.64-4.04)	0.311	80 (13)	19 (24)	1.00 (0.46-2.16)	0.993
>$100,001	88 (14)	†	Reference	Ref	63 (10)	15 (24)	Reference	Ref
Household income ≤NZ$50,000	296 (48)	68 (23)	1.82 (1.20-2.76)	0.005	319 (38)	87 (27)	1.17 (0.81-1.69)	0.370
Deprivation (NZDep 2006)					-	-	-	-
1 – 3 (least deprived)	78 (10)	†	Reference	Ref	29 (3)	†	Reference	Ref
4 – 7	234 (30)	39 (27)	1.75 (0.82-4.20)	0.175	132 (16)	29 (14)		

8 – 10 (most deprived)	465 (60)	99 (68)	2.37 (1.17-5.48)	0.027	677 (81)	183 (86)	1.55 (1.03-2.42)	0.043
High crowding index, 9 months	272 (35)	56 (21)	1.20 (0.82-1.73)	0.386	487 (58)	134 (28)	1.30 (0.95-1.79)	0.110
Total household numbers >5, 9 months	196 (25)	41 (28)	1.20 (0.80-1.80)	0.398	365 (43)	105 (29)	1.36 (1.00-1.86)	0.056
Daycare attendance, 9 months	114 (15)	19 (17)	0.84 (0.50-1.43)	0.605	62 (7)	20 (32)	1.44 (0.82-2.51)	0.225
Resident in an urban region	730 (94)	142 (19)	2.60 (0.92-7.35)	0.081	832 (99)	212 (26)	1.20 (0.25-5.81)	1.000
Maternal smoking in pregnancy	313 (40)	68 (22)	1.37 (0.96-1.97)	0.092	240 (29)	77 (32)	1.60 (1.15-2.23)	0.007
Maternal smoking, 9 months	306 (39)	71 (23)	1.60 (1.11-2.29)	0.014	190 (23)	65 (34)	1.75 (1.23-2.49)	0.002
Household smoking, 9 months	436 (56)	94 (22)	1.53 (1.05-2.22)	0.027	431 (51)	118 (27)	1.23 (0.90-1.68)	0.205
Bathing of child < daily, 9 months	271 (35)	58 (21)	1.29 (0.89-1.87)	0.178	387 (46)	106 (27)	1.21 (0.89-1.65)	0.235

ID=infectious disease; OR=odds ratio; CI=confidence interval; NZDep2006= New Zealand Index of Deprivation derived from the 2006 national census.

† Cells containing less than 10 participants have had absolute numbers and percentages withheld to protect participant anonymity.

TABLE 5. Multivariable logistic regression of hospitalisation for infection in the first year of life in relation to infant and maternal factors, for infants of Māori and Pacific mothers

	Infants of mothers of Māori ethnicity (n=777)		Infants of mothers of Pacific ethnicity (n=841)	
Variable	**AOR (95% CI)**	**p-value**	**AOR (95% CI)**	**p-value**
Child factors				
Birthweight <2500 g			2.06 (0.83-4.94)	0.108
Exclusive breastfeeding < 4 months†			1.35 (0.97-1.86)	0.073
Healthcare				
Delayed or incomplete routine vaccinations, 9 months			1.72 (1.23-2.38)	0.001
Maternal prior experience of racism from health care provider			2.20 (1.29-3.70)	0.003
Socio-demographics				
Deprivation (NZDep2006)				
1 – 2 (least deprived)	Reference	Reference	Reference	Reference
4 – 7	1.73 (0.81-4.15)	0.185		
8 – 10 (most deprived)	2.16 (1.06-5.02)	0.049	1.49 (0.97-2.35)	0.075
Maternal smoking, 9 months	1.48 (1.02 - 2.14)	0.040	1.59 (1.10-2.29)	0.013

AOR=adjusted odds ratio; CI=confidence interval; NZDep2006=New Zealand Index of Deprivation derived from the 2006 national census.

† Includes infants who were not breastfed at all

Figure 1 Legend

Figure 1: Flow diagram describing numbers of cohort participants and numbers with ID hospitalisation.

Figure 1 footnote:

Note: a child admitted more than once in the first year of life is counted only once in the total number of children experiencing ID hospitalisation but may be counted more than once when broken down by type of infection.

Abbreviations: *n* = number of children, Resp. = respiratory infection, GI = gastrointestinal infection, SSTI = skin and soft tissue infection, GU = genitourinary infection, Cong. = congenital and perinatal infection.