

ORIGINAL ARTICLE

Paediatric food-induced anaphylaxis hospital presentations in New Zealand

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Aim: Globally, rates of paediatric food-induced anaphylaxis (FIA) are increasing. Little data is available regarding the epidemiology of FIA among New Zealand (NZ) children. This study investigated the incidence of paediatric (0–14 years) FIA hospital presentations in NZ over a 10-year period.

Methods: Ministry of Health public hospital discharge data from 2006 to 2015 were analysed using FIA-related International Classification of Diseases codes (T78.0 – anaphylactic shock due to adverse food reaction and T78.2 – anaphylactic shock unspecified and free text qualifier) to identify acute hospital presentations.

Results: The overall annualised FIA hospital presentation rate was 16.2 per 100 000 children. Subgroup analysis indicated a significantly higher rate in males (19.1/100 000) than in females (13.1/100 000), and among children aged less than 2 years of age (50.5/100 000) compared with older children. Rates among Asian and Pacific children were higher than Māori and NZ European children. In 67.7% of cases, a single specific allergen was suggested by the information provided; among these cases, nuts (48%), specifically peanuts (26%), were the most commonly reported allergen, followed by cow's milk (21%). Time trend analysis showed a 2.8-fold increase in the overall annualised rate for the 10-year period.

Conclusion: These findings are consistent with other international studies indicating increasing rates of FIA in children. These data will provide information for a review of NZ paediatric allergy services to ensure current international standards with regard to the equitable delivery of timely, appropriate and accessible care are being met. Reasons for differences by gender, age and ethnicity require further investigation.

Key words: children; food-induced anaphylaxis; hospital presentations; New Zealand; paediatric.

What is already known on this topic

- 1 Food is the major trigger of anaphylaxis in children.
- 2 Globally, rates of paediatric food-induced anaphylaxis (FIA) are increasing.
- 3 Little data is available regarding the epidemiology of FIA among New Zealand (NZ) children.

What this paper adds

- 1 FIA admission rates in NZ among children were significantly higher in males and among children aged less than 2 years of age.
- 2 FIA admission rates in NZ among children were higher among Asian and Pacific children than Māori and NZ European children.
- 3 Time trend analysis showed a 2.8-fold increase in the overall annualised rate of admissions for FIA among children (1–14 years) in NZ for the 10-year period reviewed.

An increasing prevalence of food allergy among children has been identified in many countries.^{1–4} Studies using food challenges and standardised methodology are providing new insights into food allergy rates across different geographic areas.³ Egg and milk are the most commonly reported food allergens in infants and young children,¹ with many but not all cases resolving over time.² In older children and adults, fish and shellfish, and

peanuts and tree nuts are major allergens in much of the developed world. Childhood food allergy often persists into adult life and is associated with severe, potentially fatal, reactions. Both ethnicity and environment appear relevant to the variations in the responsible food allergens in different geographic regions, with interactions between these of potential importance.^{3,5–7}

Anaphylaxis, a rapid onset severe allergic reaction, is the most severe manifestation of food allergy.^{8–10} Food is the major trigger of anaphylaxis in children.^{8,9} The impacts of child food-induced anaphylaxis (FIA) for children and their families are significant. Affected children have a reduced quality of life often due to limited family outings, restrictions on eating outside the home, reduced school attendance, anxiety and depression and poor perceptions of general health.^{11–13} Parents and caregivers are affected by holding the burden of responsibility, psychological

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Conflict of interest: None declared.

Accepted for publication 8 August 2017.

distress, frustrations with a lack of public understanding, unclear food labelling and the substantial associated costs.^{11–13}

International studies suggest rates of FIA in children are increasing,^{9,14–17} as evidenced by increasing prescribing of allergy-related medicines, for example, infant hypoallergenic formula, child epinephrine auto-injectors^{18,19} and FIA emergency department (ED) visits and hospital admissions.^{8,14,20} US data indicate rates of paediatric FIA-related ED visits in recent years have increased up to twofold,^{8,21} with similar patterns seen for hospital admissions.^{8,22} An Australian study reported rates of FIA-related admissions among young children (0–4 years) rose from 21.7 in 2005/2006 to 30.3 in 2011/2012 and among older children (5–14 years) from 5.8 to 12.1 per 100 000.¹⁴ An analysis of 20 years of UK FIA trends (1992–2012) found paediatric admissions (0–14 years) rose by 137% (rate ratio 1.05; 95% confidence interval (CI) 1.05–1.06; $P < 0.001$).²⁰ Hospital admission data for FIA from the Italian Ministry of Health for the 6 years from 2006 to 2011 revealed an FIA admission rate of 4.4 per 100 000 children/year, with a north–south gradation apparent.²³ This geographical gradation has previously been reported in the USA and Australia and has raised the question of the role of vitamin D deficiency in food allergy.^{5,24}

Comparing rates of FIA between different populations can be complex as a result of the heterogeneity of diagnostic criteria, study designs and methodologies employed. In addition, details of the responsible food are not always available or recorded in cases of FIA.²⁵ Very little is known about the incidence of FIA among New Zealand (NZ) children (<15 years of age).²⁶ However, a recent study investigated the incidence of FIA in NZ adults, resulting in presentation to a public hospital ED.²⁵ This study showed an increased rate over the 10-year period from 3.3 per 100 000 people in 2002 to 5.8 per 100 000 people in 2011 with the greatest increase in attendances seen in Pacific peoples.²⁵

In the current study, we have examined the incidence of FIA resulting in public hospital attendance/admission in children in NZ, detailing patient characteristics, food allergens and time trends with the aim of adding to the international body of evidence providing insight into rates and causes of FIA.

Methods

Paediatric (1–14 years) acute public hospital FIA presentations over a 10-year period (2006–2015 inclusive) to NZ Public hospitals were reviewed. NZ has a population of 4 353 190, of which 20% are children (<15 years), around 52% of whom identify as NZ European, Other or Middle Eastern/Latin American/African, 23% Māori (NZ's indigenous population), 9% Pacific peoples and 10% Asian.²⁷

Routine coded discharge data were obtained from the Ministry of Health's National Minimum Dataset (NMDs). Cases were identified using the International Classification of Diseases tenth revision (ICD-10 AM) codes recorded in the first two diagnostic fields. Previous NZ research using NMDs data found 99% of adult FIA cases were located by identifying relevant FIA codes in these diagnostic fields.²⁵ Selected ICD codes were based on a review of the published literature and advice from specialists in the field, and included codes T78.0 (anaphylactic shock due to adverse food reaction) and T78.2 (anaphylactic shock

unspecified). Code T78.2 was included only if consumption of food or specific food types were mentioned in the corresponding text field. If the presentation category was non-acute and the place was a health-care institution or an immunology service, then the anaphylaxis was assumed to be the result of a food challenge and excluded. Only primary presentations were included in the study.

Variables analysed included demographic information, and ICD diagnostic codes with free text descriptions. Guided by the free text descriptions, an allergen category was assigned: cow's milk; egg; fruit and vegetable; tree nut, peanut, nut-unspecified (general 'nut' terminology used); fish, shellfish, seafood not further specified; wheat/gluten; other food (specific allergen that did not fit into another category); and 'unknown/not reported'. In cases where broad terms containing many potential allergens (e.g. muffin) were used or where two or more specific allergens were mentioned (e.g. chocolate Brazil nut), the allergen was classified as 'unable to determine'. As specific information regarding 'ED only' stays were unavailable, we assumed a length of stay <24 h related to an ED visit.

Analyses were conducted using Excel. NZ Census data (2013) was used as the denominator to determine age-specific and ethnic-specific rates per 100 000 children. Denominator data for Pacific or Asian subgroups were not available. Differences in rates and proportions were assessed using the z-score and the χ^2 test, respectively. As the study used routinely collected anonymised data, national Ethics Committee approval was not required.

Results

During the 10-year period reviewed, we identified 1441 FIA paediatric (0–14 years) public hospital ED presentations, an average annualised rate of 16.2 per 100 000 children (95% CI 15.4–17.0). Of these, 1381 (96%) were coded as FIA (T78.0), and 60 (4%) as unspecified anaphylaxis (T78.2) with an accompanying food-induced text description (Table 1). The majority of the T78.0 ('anaphylactic shock due to adverse food reaction'; 97.2%) and T78.2 ('anaphylactic shock unspecified' + free text qualifier; 98.3%) codes were located in the first of the two diagnostic fields of the NMDs record. The majority of children were in hospital for less than 48 h (96.8%; $n = 1395$) (Table 1).

Significant differences in FIA rates by gender were observed (Table 1). The rate of FIA among males was 1.5 times that of female (19.1/100 000 children vs. 13.1/100 000 children). Males were more likely to have FIA than females across all age groups; however, in children aged 2–4 years, this difference was most apparent (64.4% males and 35.6% females). This trend steadily declined with increasing age.

Rates were highest among children aged less than 2 years of age (50.5/100 000 children), almost six times the rate seen in 10–14-year-olds (8.6/100 000 children). The rate among pre-school children (0–4 years) was 30.7/100 000 children. Rates were highest among Asian children (29.7/100 000 children) and Pacific children (27.8/100 000 children), and lowest among Māori children (12.8/100 000 children).

In 80.7% of cases ($n = 1163$), a food allergen was recorded; however, in 187 of these (16.1%) the specific allergen was unable to be determined (e.g. 'cake') (Fig. 1). Of the 976 cases in which a single allergen was able to be determined, peanut was

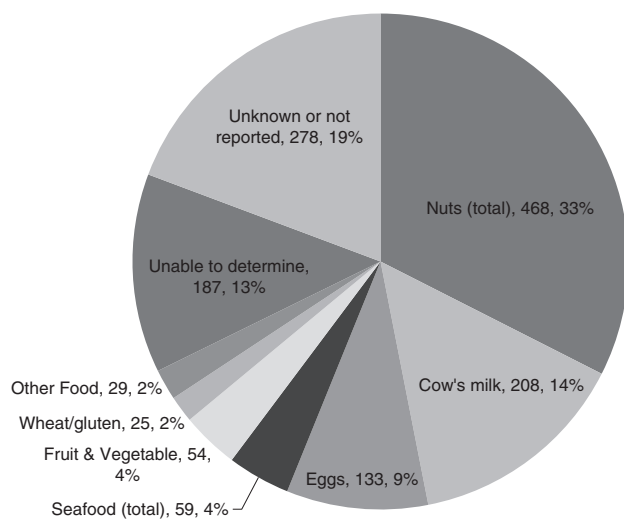
Table 1 Characteristics of child (<15 years) hospital presentations with a discharge diagnosis of food-induced anaphylaxis† (*n* = 1441), New Zealand, 2006–2015

Characteristic	<i>n</i> (%)	Annualised rate per 100 000 (95% CI)†
Gender		
Male	872 (60.5)	19.1 (17.9, 20.4)
Female	569 (39.5)	13.1 (12.1, 14.2)
Age group (years)		
<2	575 (39.9)	50.5 (46.5, 54.7)
2–4	323 (22.4)	18.1 (16.2, 20.2)
5–9	297 (20.6)	10.4 (9.2, 11.6)
10–14	246 (17.1)	8.6 (7.6, 9.7)
Ethnicity‡		
Māori	258 (17.9)	12.8 (11.3, 14.4)
Pacific people	213 (14.8)	27.8 (24.3, 31.8)
Asian	265 (18.4)	29.7 (26.4, 33.5)
New Zealand European and other	699 (48.8)	15.4 (14.3, 16.6)
Codes		
T78.0	1381 (96.0)	Not calculated
T78.2	60 (4.0)	Not calculated
Length of stay		
<24 h	705 (48.9)	Not calculated
1 day	690 (47.9)	Not calculated
2 days	32 (2.2)	Not calculated
>2 days	14 (1.0)	Not calculated

†International Classification of Diseases (ICD) codes T78.0 and T78.2.

‡Ethnicity was not recorded in six cases. CI, confidence interval.

the most common (*n* = 252, 25.8%), followed by cow's milk (*n* = 208, 21.3%). Wheat/gluten was the least common food allergen recorded accounting for only 2.6% of cases (*n* = 25). In almost half of cases (*n* = 468; 48%), nuts (peanut, tree nuts or nuts unspecified) were recorded as the allergen.

**Fig. 1** Food allergen categories for food-induced anaphylaxis cases in children (<15 years), New Zealand, 2006–2015.

Peanut was the most common food allergen for children aged 2–4 years (17.6%), 5–9 years (18.9%) and 10–14 years (22.8%), while cow's milk was the most prevalent in children aged less than 2 years (19.5%) (Table 2). As age increased so did the frequency of peanut and seafood being reported as the allergen responsible for the FIA episodes resulting in presentation to hospital, and the frequency of eggs and cow's milk diminished. Peanut was the most common food allergen recorded in Māori (21.7%), Pacific people (18.9%), NZ European/Other (17.2%) and children of 'unknown' ethnicity (33.3%) presentations, while cow's milk (19.3%) was the most predominant food allergen in Asian children. Note that in Table 2, 'nut' related incorporates peanuts, tree nuts and nuts unspecified allergens. The mean age of FIA presentations was similar among Asian, Māori and Pacific children (3.4, 3.7 and 3.6 years, respectively), but higher for NZ European/Other children (5.0 years) and children of unknown ethnicity (11.3 years).

Over the 10-year period reviewed, annual rates of paediatric FIA hospital presentations almost tripled (2.8 times) from 8.4 per 100 000 children in 2006 to 24.0 per 100 000 in 2015 (Fig. 2). The greatest increase was seen among 0–4-year-olds, where the rate increased 2.5 times (18.1 to 45.5/100 000 children) of the period reviewed.

Stratifying the data by ethnicity revealed the largest rate increase (among cases where ethnicity was recorded) was among Asian children (from 10.1/100 000 in 2006 to 69.6 in 2015) and lowest among Māori children (from 5.9/100 000 in 2006 to 17.3/100 000 in 2015) (Fig. 3).

Discussion

This study has identified an overall annualised incidence rate of FIA hospital presentations in NZ children of 16.2 per 100 000 children and also identified gender, age and ethnic disparities in incidence rates. Males, younger children (<2 years) and Asian and Pacific populations had higher rates of FIA than other subgroups. Nuts as a food group (includes peanuts, tree nuts and unspecified nuts) were recorded in almost half (48%) of the cases where a single allergen was able to be determined from the information recorded. Peanut was the most common single allergen (26%), followed by cow's milk (21%). The frequency of certain allergens differed by age and ethnicity, with cow's milk the most common for children aged less than 2 years (19.5%), and peanuts most common (19.6%) for older children (2–14 years).

The incidence of paediatric FIA found in this study (16.2/100 000 children) is consistent with international studies.^{9,14,16} No previous NZ studies were found that had estimated FIA hospital presentation rates in children. The current study found a 2.8-fold increase in incidence of hospital presentations for FIA in children. That seen in the NZ adult population between 2002 and 2011 was somewhat lower, with a 1.8-fold increase.²⁵ As in the current study, rates were higher in the younger age groups. These increases are consistent with increased underlying food allergy as a cause, but contribution from increased reporting or increased exposure to anaphylaxis triggers may contribute. The highest rates were in children under 2 years of age (50.5/100 000 children). International studies have also noted an increase in FIA rates in children.^{9,14–17}

Table 2 Food allergen by age group and ethnicity for paediatric (<15 years) hospital presentations for food-induced anaphylaxis to New Zealand hospitals, 2006–2015 (*n* = 1441)

Characteristics	Food type									
	Eggs, <i>n</i> (%)	Cow's milk, <i>n</i> (%)	Seafood, <i>n</i> (%)†	Fruit and vegetable, <i>n</i> (%)	Nuts, <i>n</i> (%)‡	Wheat/ Gluten, <i>n</i> (%)	Other food, <i>n</i> (%)	Unable to determine, <i>n</i> (%)	Unknown/ Not reported, <i>n</i> (%)	Total, <i>n</i> (%)
Age group (years)										
<2	99 (17.2)	112 (19.5)	10 (1.7)	19 (3.3)	130 (22.6)	12 (2.1)	9 (1.6)	71 (12.3)	113 (19.7)	575 (40.0)
2–4	23 (7.1)	41 (12.7)	12 (3.7)	10 (3.1)	128 (39.8)	3 (0.9)	13 (4.0)	35 (10.8)	58 (18.0)	323 (22.4)
5–9	7 (2.4)	36 (12.1)	15 (5.1)	8 (2.7)	118 (39.7)	8 (2.7)	5 (1.7)	43 (14.5)	57 (19.2)	297 (20.6)
10–14	4 (1.6)	19 (7.7)	22 (8.9)	17 (6.9)	92 (37.4)	2 (0.8)	2 (0.8)	38 (15.4)	50 (20.3)	246 (17.1)
Ethnicity										
Māori	29 (11.2)	24 (9.3)	12 (4.7)	8 (3.1)	90 (34.9)	4 (1.6)	0 (0.0)	36 (14.0)	55 (21.3)	258 (17.9)
Pacific	15 (7.1)	37 (17.5)	15 (7.1)	10 (4.7)	56 (26.4)	1 (0.5)	6 (2.8)	29 (13.7)	44 (20.8)	213 (14.8)
Asian	33 (12.5)	51 (19.3)	9.0 (3.4)	11 (4.2)	74 (28.0)	8 (3.0)	5 (1.9)	42 (15.9)	32 (12.1)	265 (18.4)
New Zealand European and other	56 (8.0)	96 (13.7)	22.0 (3.1)	24 (3.4)	246 (35.2)	12 (1.7)	18 (2.6)	80 (11.4)	145 (20.7)	699 (48.6)
Unknown	0 (0.0)	0 (0.0)	1.0 (16.7)	1 (16.7)	2 (33.3)	0 (0.0)	0 (0.0)	0 (0.0)	2 (33.3)	6 (0.4)

†Includes fish, shellfish and seafood unspecified. ‡Includes peanuts, tree nuts and nuts unspecified.

Mullins *et al.* reviewed 681 207 hospital admissions for allergic conditions (anaphylaxis, asthma, urticaria, angioedema) from the Australian National Hospital Morbidity Database for the period 2005/2006 to 2011/2012, and found a 1.5-fold increase in hospital admission rates for FIA across all ages from 5.6/100 000 to 8.2/100 000 over the 7-year period.¹⁴ The highest rates were in children aged 0–4 years (30.3 in 2011–2012),¹⁴ comparable with the rate for the same age group found in the present study (30.7/100 000). Further subgroup analysis revealed rates were highest in very young children (0–2 years, 50.5/100 000). Poulos *et al.* in their review of Australian hospital presentations over an 11-year period (1993/1994 to 2004/2005) found the greatest increase in FIA admissions was observed among 0–4-year-olds (5.5-fold increase).¹⁶ Mullins examined 1489 children aged 0–5 years referred to a community-based specialist allergy practise in the Australian Capital Territory between 1995 and

2006, and found the prevalence of FIA increased from 9 to 15.4% over the 12-year period.¹⁵ The NZ paediatric rates overall in this study appear comparable with those identified in Australia in recent years.

In the present study, there were significantly higher rates in males (19.1/100 000 vs. 13.1/100 000 in females) as identified in previous studies.¹⁶ Asian (29.7/100 000) and Pacific (27.8/100 000) children had the highest rates of FIA in the present study, while Māori children had the lowest rates (12.8/100 000 children). We were unable to calculate ethnic-specific rates for Asian subgroups due to a lack of available denominator data. Of note, the composition of the Asian group was 43% 'Chinese', 29% 'Southeast Asian', 21.5% 'Indian', 20% 'Other Asian' and 4.5% were classified as 'Asian not further defined'. This study has used 2013 census denominator data to calculate presentation rates; changes in patterns of immigration may in part explain the higher rates among Asian children if the Asian population

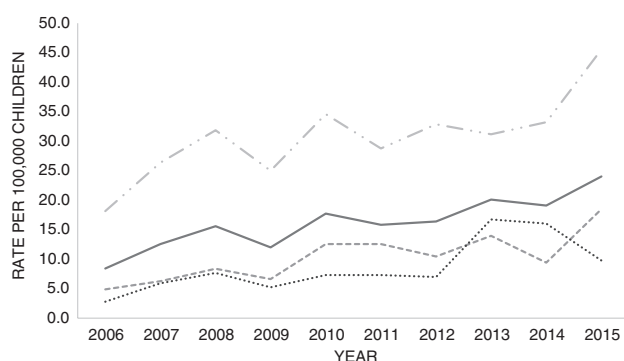


Fig. 2 Trends in child (<15 years) hospital presentations for food-induced anaphylaxis (rate per 100 000 children), New Zealand, 2006–2015. (—), Total; (---), 0–4 years; (.....), 5–9 years; (-.-.-), 10–14 years.

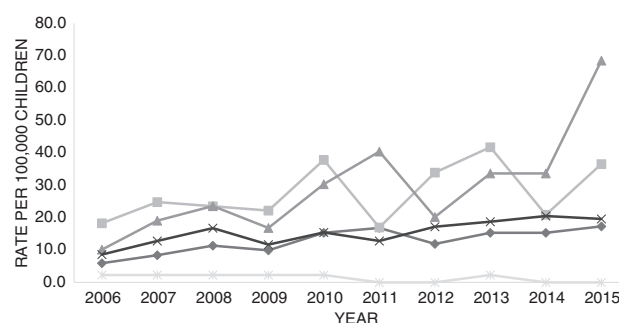


Fig. 3 Trends in child (<15 years) hospital presentations for food-induced anaphylaxis by ethnicity (rate per 100 000 people), New Zealand, 2006–2015. (—●—), Māori; (—■—), Pacific people; (—▲—), Asian; (—×—), New Zealand European and other; (---*), unknown.

numbers have increased significantly since the last census. Between the two most recent census periods (2006 and 2013), the Asian population had the greatest increase out of the four main population groups (Māori Pacific, Middle Eastern/Latin American/African), increasing by 2.6% it is likely that this trajectory has continued.²⁸

An analysis of a cohort of nearly 60 000 school entrants in Australia found a significantly higher rate of parentally reported nut allergy in children born in Australia to Asian-born mothers (adjusted odds ratio 2.67; 95% CI 2.28–3.27) than non-Asian children, although children born in Asia who subsequently migrated were not at elevated risk (indeed there appeared to be a protective effect).²⁹ We do not have data regarding place of birth for our study population, but many of the Asian and Pacific children included are likely to be NZ born. The causes for increased allergy rates in children of immigrants are uncertain. Both vitamin D deficiency and alteration of microbiota have been suggested as potentially influential.

A previous NZ study in adults, which used similar methodology to the present study, reported the greatest increase in adult FIA hospital presentations during 2002–2011 was among Pacific people (6.0 to 20.6 per 100 000 people).²⁵ Māori (1.4 to 5.7 per 100 000 people), Asians (4.1 to 5.5 per 100 000 people) and people of NZ European and 'Other' ethnicities (3.5 to 5.2 per 100 000 people) had more modest increases over the 10-year period reviewed.

In 81% of cases in the present study, the allergen (or suspected allergen) was reported; however, we were only able to determine a single specific allergen in 68% of cases. The predominance of nuts as the most common allergen in this study is consistent with international studies that have identified peanuts and tree nuts as the leading cause of FIA among children³ and indeed across all ages.⁹ In the previous NZ adult study, a single specific allergen able to be determined in only 21% of cases, with seafood the most common allergen (31%), closely followed by nuts (30%).²⁵

The strengths of this study include the use of routinely collected population-based data, and the use of internationally recognised diagnostic codes to identify cases. Potential limitations include the possibility of misdiagnosis resulting from miscoding or a lack of sufficient information. There have been no evident changes to diagnostic criteria or hospital practice that may have altered incidence rates over time. However, a recent NZ study suggested that 29% of the 221 presentations to a large public hospital (1988–2011 data) assigned a code of 'anaphylaxis, unspecified' or 'allergy, unspecified' were food-related.³⁰ It is unclear how many of these cases would not have been identified by incorporating our use of the text field inclusion of food, but the number overall seems likely to be relatively small.

The NMDS data used for this study do not include children whose FIA was managed in other primary care settings and therefore may underestimate overall rates. Identification of the responsible food allergens was not confirmed by individual case follow-up and misattributions may have occurred. Furthermore, in 32.3% of cases the allergen was not identifiable or not reported.

Conclusion

This research provides insight into the increasing incidence rate of FIA in NZ children, broadly similar to that seen in other

developed countries. Reasons for the differential rates seen in Asian and Pacific children require further investigation, but may include genetic and environmental factors.

Acknowledgements

S Speakman was the recipient of a University of Auckland Summer Research Studentship supported by the University of Auckland.

References

- Prescott S, Pawankar R, Allen K *et al.* A global survey of changing patterns of food allergy burden in children. *World Allergy Organ J.* 2013; **6**: 1–12.
- Koplin J, Wake M, Dharmage S *et al.* Cohort profile: The HealthNuts Study: Population prevalence and environmental/genetic predictors of food allergy. *Int. J. Epidemiol.* 2015; **44**: 1161–71.
- Osborne NJ, Koplin JJ, Martin PE *et al.* Prevalence of challenge-proven IgE-mediated food allergy using population-based sampling and pre-determined challenge criteria in infants. *J. Allergy Clin. Immunol.* 2011; **127**: 668–76.e1–2.
- Schoemaker AA, Sprickelman AB, Grimshaw KE *et al.* Incidence and natural history of challenge-proven cow's milk allergy in European children: EuroPrevall birth cohort. *Allergy* 2015; **70**: 963–72.
- Allen K, Koplin J, Ponsonby A *et al.* Vitamin D insufficiency is associated with challenge-proven food allergy in infants. *J. Allergy Clin. Immunol.* 2013; **4**: 1109–16.e6.
- Sicherer SH, Munoz-Furlong A, Godbold JH, Sampson HA. US prevalence of self-reported peanut, tree nut, and sesame allergy: 11-year follow-up. *J. Allergy Clin. Immunol.* 2010; **125**: 1322–6.
- Koplin J, Peters R, Ponsonby A *et al.* Increased risk of peanut allergy in infants of Asian-born parents compared to those of Australian-born parents. *Allergy* 2014; **69**: 1639–47.
- Dyer A, Lau C, Smith T, Smith B, Gupta R. Pediatric emergency department visits and hospitalizations due to food-induced anaphylaxis in Illinois. *Ann. Allergy Asthma Immunol.* 2015; **115**: 458.
- Vetander M, Helander D, Flodström C *et al.* Anaphylaxis and reactions to foods in children – A population-based case study of emergency department visits. *Clin. Exp. Allergy* 2012; **42**: 568–77.
- Brown S, Mullins R, Gold M. Anaphylaxis: Diagnosis and management. *Med. J. Aust.* 2006; **185**: 283–9.
- Sicherer SH, Noone SA, Muñoz-Furlong A. The impact of childhood food allergy on quality of life. *Ann. Allergy Asthma Immunol.* 2001; **87**: 461–4.
- Akeson N, Worth A, Sheikh A. The psychosocial impact of anaphylaxis on young people and their parents. *Clin. Exp. Allergy* 2007; **37**: 1213–20.
- Cummings AJ, Knibb RC, King RM, Lucas JS. The psychosocial impact of food allergy and food hypersensitivity in children, adolescents and their families: A review. *Allergy* 2010; **65**: 933–45.
- Mullins R, Dear K, Tang M. Time trends in Australian hospital anaphylaxis admissions in 1998–1999 to 2011–2012. *J. Allergy Clin. Immunol.* 2015; **136**: 367–75.
- Mullins R. Paediatric food allergy trends in a community-based specialist allergy practice, 1995–2006. *Med. J. Aust.* 2007; **186**: 618–21.
- Poulos L, Waters A, Correll P, Loblay R, Marks G. Trends in hospitalisation for anaphylaxis, angioedema, and urticaria in Australia, 1993–1994 to 2004–2005. *J. Allergy Clin. Immunol.* 2007; **120**: 878–84.
- Rudders SA, Banerji A, Vassallo MF, Clark S, Camargo CA Jr. Trends in pediatric emergency department visits for food-induced anaphylaxis. *J. Allergy Clin. Immunol.* 2010; **126**: 385–8.

- 18 Mullins RJ, Clark S, Camargo CAJ. Regional variation in infant hypoallergenic formula prescriptions in Australia. *Pediatr. Allergy Immunol.* 2010; **21** (2 Pt 2): e413–20.
- 19 Mullins RJ, Clark S, Camargo CAJ. Regional variation in EpiPen prescriptions in Australia: More evidence for the vitamin D-anaphylaxis hypothesis. *Ann. Allergy Asthma Immunol.* 2009; **103**: 488–95.
- 20 Turner PJ, Gowland MH, Sharma V, Ierodiakonou D, Harper N, Garcez T. Increase in anaphylaxis-related hospitalizations but no increase in fatalities: An analysis of United Kingdom national anaphylaxis data, 1992–2012. *J. Allergy Clin. Immunol.* 2015; **135**: 956–63.
- 21 Panjari M, Koplin JJ, Dharmage SC *et al.* Emergency and hospital care for food-related anaphylaxis in children. *Hosp. Pediatr.* 2016; **6**: 269–74.
- 22 Rudders S, Arias S, Camargo C. Trends in hospitalizations for food-induced anaphylaxis in US children, 2000–2009. *J. Allergy Clin. Immunol.* 2014; **134**: 960–2.e3.
- 23 Nocerino R, Leone L, Cosenza L, Berni C. Increasing rate of hospitalizations for food-induced anaphylaxis in Italian children: An analysis of the Italian Ministry of Health database. *J. Allergy Clin. Immunol.* 2015; **35**: 833–5.
- 24 Vassallo M, Camargo CA. Potential mechanisms for the hypothesized link between sunshine, vitamin D, and food allergy in children. *J. Allergy Clin. Immunol.* 2010; **126**: 217–22.
- 25 Kool B, Chandra D, Fitzharris P. Adult food-induced anaphylaxis hospital presentations in New Zealand. *Postgrad. Med. J.* 2016; **92**: 640–4.
- 26 Empson M, Smith J. Anaphylaxis rates in New Zealand. *World Allergy Organ J.* 2007; **1** (Suppl. 3): S207.
- 27 Statistics New Zealand. *Data Tables 2013 Census*. Wellington: Statistics New Zealand, 2013. Available from: <http://www.stats.govt.nz/Census/2013-census/data-tables.aspx> [accessed 15 March 2017].
- 28 Ho E. The changing face of Asian peoples in New Zealand. *N. Z. Popul. Rev.* 2015; **41**: 95–118.
- 29 Panjari M, Koplin JJ, Dharmage SC *et al.* Nut allergy prevalence and differences between Asian-born children and Australian-born children of Asian descent: A state-wide survey of children at primary school entry in Victoria, Australia. *Clin. Exp. Allergy* 2016; **46**: 602–9.
- 30 McMilin C, Camargo C, Morton S, Grant C. Understanding administrative coding of emergency department visits for unspecified acute allergic reactions. *N. Z. Med. J.* 2015; **128**: 39–46.