

EPIDEMIOLOGY OF FOOD ALLERGY

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ABSTRACT

The prevalence of food allergies has increased in the past 2 decades particularly in developed countries, but with recent evidence of an increase in developing countries too. Despite this change in prevalence, the most common allergenic foods remain cow’s milk, hen’s egg, wheat, soya, fish, shellfish, peanut and tree nuts.

Food allergy prevalence studies are thwart with inherent difficulties, and using self-report or sensitisation patterns is an inaccurate measure of food allergy prevalence. Food challenge testing is the optimal way of proving food allergy, albeit labour and cost-intensive. Large population studies and meta-analyses of studies, using food challenges, have shown a wide variation in food allergy prevalence, ranging from 1% to over 10%, depending on the age of the child and the region studied. The prevalence of food allergy in South Africa is currently unknown, though thought to be on the increase. This is currently being investigated in a large population based study in the Western Cape. Risk factors for food allergy are both genetic and environmental, such as diet and microbial diversity. Children with eczema are at particular risk of food allergy because of cutaneous exposure to allergens.

INTRODUCTION

Food allergy represents a significant public health concern. The prevalence of food allergy varies significantly based on geographical region, allergens tested, criteria used for diagnosing food allergy, age of the population, setting of the population sample and intercurrent atopic conditions.¹ Variations in the definition of food allergy and inconsistencies in study design make studies on food allergy prevalence difficult to compare. Self-report significantly over-estimates food allergy prevalence by up to 10-fold,² hence objective measurements are necessary to establish a true food allergy diagnosis. Similarly, sensitisation to foods is much higher than clinically relevant allergies hence sensitisation should always be combined with more objective information to

prove allergies. Recent large population based studies such as the EuroPrevall® study in Europe² and HealthNuts® study in Australia³ have utilised food challenge testing and can be considered flagship studies of food allergy prevalence.

ALLERGENIC FOODS

Despite the large number of food that can cause IgE-mediated reactions, most prevalence studies have focused on the most common allergenic foods, namely cow’s milk, hen’s egg, peanut, tree nut, wheat, soya, fish and shellfish. Such allergens account for up to 90% of food allergy reactions. Other food allergens may be particularly prevalent in certain geographical areas, for example peaches in Mediterranean countries. The most common

Table I: Most common allergens by age

Most common allergens in children	Most common allergens in adults
Cow’s milk	Fish
Hen’s egg	Shellfish
Peanut	Peanut
Tree nut	Tree nut
Soya	Fruits
Wheat	Vegetables
Sesame	

food allergens by age are depicted in Table I.⁴

PREVALENCE OF FOOD ALLERGY

Taking into account different definitions and methodologies used in food allergy prevalence studies, several meta-analyses and large cohort studies, mostly in the US, UK, Europe and Australia, have estimated food allergy prevalence in these regions.

A meta-analysis of food allergy of 51 studies investigating food allergy to cow's milk, hen's egg, peanut, fish and shellfish in children up to 18 years showed self-reported food allergy to vary between 3 and 35%.² Challenge proven food allergy in these studies was between 1% and 10.8% (on average 0.9% to milk, 0.3% to egg, 0.3% to fish). A recently published European meta-analysis showed a challenge proven food allergy rate of 1% in children.⁵ A German study assessing doctor-diagnosed food allergy prospectively reported a rate of 4.6% at 1 year, 6.6% at age 2 and 3.9% at ages 3-6.⁶ A birth cohort study in the UK utilising oral food challenges showed cumulative incidence of 6% at 3 years.⁷ A Danish birth cohort study showed that 3.7% of children had a positive food challenge by 6 years age,⁸ and a similar Danish study on young adults showed a prevalence of 1.7%.⁹ An Israeli study based on sensitisation and strong history reported a food allergy prevalence of 1.2% with a uniquely high proportion of sesame allergy.¹⁰

A study in the United States (US) analysing data from an infant feeding practices study showed probable food allergy, food-related symptoms or doctor-diagnosed allergy, in 6% of one year olds.¹¹ A subsequent US national health survey estimated 3.9% of children to be affected by food allergy, based on specific IgE levels to foods; mostly milk (0.4%), egg (0.2%), peanut (1.3%) and shrimp (1%).^{12,13} The recently published HealthNuts® study from Australia showed more than 10% prevalence of challenge proven food allergy to common allergens of childhood in 1 year olds (3% to peanut, 8.9% to raw egg, 0.8% to sesame).³

Studies from developing countries show varying prevalence of food allergy. Recent studies from China show challenge-proven food allergy rates of 3.8-7.3%,^{14,15} and a Thai study shows a challenge proven food allergy rate of 0.45%.¹⁶ Food allergy prevalence from large population-based studies and meta-analyses are summarised in Table II. (see next page)

The prevalence of food allergy in an unselected population in South Africa is unknown and is currently being studied in the Western Cape in the South African Food Sensitisation and Food Allergy prevalence study (SAFFA study).

In summary, food allergy peaks in the first 2 years of life. It then diminishes towards late childhood as tolerance to several foods develops over time. The true incidence of food allergy varies from 1% to over 10% depending on the geographical area and age of the patient studied. The prevalence of food allergy in South Africa is unknown and is currently being studied.

ALLERGIES TO SPECIFIC FOODS COW'S MILK

Cow's milk allergy peaks in the first year of life and can be either IgE-mediated, non-IgE-mediated or a combination of both. Based on several studies, the documented prevalence of cow's milk allergy is between 0.3% and 3.5% of young children (under the age of 5), 17-22 less than 1% in older children, and less than 0.5% in adults.^{18,23}

Studies have indicated a generally good prognosis for cow's milk allergy, with 45-56% outgrowing the allergy by the age of one, 60-76% by age 2, 85-90% by age 3, and 97% at 15 years.^{24,25} The prognosis in a tertiary referral centre study was, however, more guarded with 5% of children outgrowing the allergy by 4 years of age and 21% by 8 years.²⁶ The prognosis of cow's milk allergy may vary according to the mechanism of the allergy. A Finnish study on cow's milk allergic children showed that those with non IgE-mediated allergy have a tolerance of 64% by age 2, 92% at 3 years, and 96% by 4 years; versus 31, 53 and 63% of those with immediate reactions respectively.²⁷

Acquisition of tolerance is faster in those with:

- initial specific IgE < 2 kU/L;
- delayed vs IgE-mediated reactions;
- absence of asthma or allergic rhinitis.^{28,29}

EGG ALLERGY

Egg allergy is more prevalent in children than in adults, and is usually IgE-mediated. The estimated prevalence is 0.5-5% in early childhood,^{17-19, 22,23,30} dropping significantly to less than 0.5% in older children and adults.^{18,22,31}

Previous studies have demonstrated a good prognosis for egg allergy, with around 50% of egg allergic children outgrowing the condition by the age of 3 years, and 66% by the age of 5.³²⁻³³ However, figures in tertiary referral centres

Table II: Summary of food allergy prevalence from meta-analyses and large population-based studies

Location (year of publication)	Study Size	Method of food allergy diagnosis	Age of patients	Prevalence of food allergy
Europe (2007) ²	Meta-analysis of 51 studies; 6 studies included food challenges	Oral food challenge	Children and adults	1-10.8% (average 3%)
Europe (2013) ⁵	Meta-analysis	Multiple	Children 0-17	Symptom + IgE 2.7% Convincing history or challenge +ve 2.6% Challenge +ve 1%
			Adults	Symptom + IgE 2.2% Challenge +ve 0.9%
Germany (2010) ⁶	1082	Doctor-diagnosed food allergy	1-6 years	4.6% (1 year) 6.6% (2 years) 3.9% (3-6 years)
UK (2008) ⁷	969	Oral food challenge	3 years	6%
Denmark (2009) ⁸	562	Oral food challenge	6 years	3.7%
Denmark (2009) ⁹	1272	Oral food challenge	Young adults	1.7%
Israel (2002) ¹⁰	9070	Food specific serum IgE with clinical symptoms	0-2 years	1.2%
USA (2008) ¹¹	2441	Questionnaire: food related symptoms or doctor diagnosed allergy	1 year	6%
USA (2010) ^{12,13}	8203	Food specific serum IgE	Children and adults	2.5% overall, 3.9% in children
China (2011) ¹⁴	497	Food challenges	0-12 months	3.8%
China (2012) ¹⁵	1604	Food challenges	0-2 years	5.5% - 7.3%
Thailand (2005) ¹⁶	656	Questionnaire Food challenges	6 months – 6 years	6.25% by questionnaire 0.45% by food challenge

are more guarded, probably reflecting a more complex patient group. A study from the USA in a tertiary referral centre has shown that 11% of children outgrew their egg allergies by the age of 4, 26% by the age of 6 years, 53% by 10 years, and 82% by age 16.³⁴

Factors associated with persistence of egg allergy include:

- high initial egg specific IgE;
- multiple food allergies;
- multiple atopic conditions;;
- ovomucoid sensitivity;
- slow decrease in specific IgE over time.³⁵

WHEAT ALLERGY

Wheat allergy is self-reported in about 4.5% of the population³⁶ but confirmed in less than 1%.^{19,21,22,23,30,31} Wheat allergy can manifest in both IgE-mediated and non-IgE mediated symptoms. The natural history of wheat allergy is less well studied, but the majority of patients tend to become tolerant by adolescence.³⁷ A study from the United States showed tolerance development in 29% by 4 years, 56% by 8 years, and 65% by 12 years.³⁸ Poorer outcomes in wheat allergy have been associated with:

- SPT wheal > 5 mm to gliadin;
- Higher wheat serum IgE levels.

FISH AND SHELLFISH ALLERGY

Fish allergy is one of the few allergies that may be more common in adulthood than childhood. A wide variety of fish and shellfish species have been implicated depending on availability and consumption patterns. A South African study of fish allergic patients showed yellowtail, hake, snoek and abalone to be the most common proven seafood allergens in patients with fish allergy.³⁹ Interestingly, in that study, only 15-21% of those patients with a perceived fish allergy had proof of allergy by sensitisation or food challenge.^{39,40}

Large US based studies have shown a prevalence of fish allergy in $\leq 0.2\%$ of children and $\leq 0.5\%$ of adults,^{18,22,30,41,42} and shellfish in $\leq 0.5\%$ of children and $\leq 2.5\%$ of adults.^{18,19,21-23,31,41,42} Seafood allergy is lifelong in the majority of cases.

PEANUT ALLERGY

Peanut allergy prevalence varies significantly between geographic regions. In the EuroPrevall study, the overall prevalence of peanut allergy was 2.6%,^{43,44} with wide variation between countries from 0.06% (Israel)¹⁰ to 5.9% (Sweden).⁴⁵ Prevalence of peanut allergy is about 0.8% of the population in the United States.⁴⁶ In a South African study of 212 Xhosa high school patients, 1.9% were sensitised to peanut but none reported allergic symptoms.⁴⁷ Experience from our food allergy clinics in South Africa, and figures on peanut allergy in eczema patients,⁴⁸ suggests that peanut allergy may now be higher than previously anticipated.

Peanut allergy usually starts in early childhood and is outgrown in only a small proportion (20%) of patients.^{49,50} A negative SPT or low level of peanut specific IgE make outgrowing the allergy more likely.

The prevalence of tree nut allergy in the US is approximately 0.5%.⁴³ The prevalence amongst European children in the EuroPrevall study varied from 0.2% (France)⁵¹ to 1.4% (UK).⁵² The prevalence may be higher in adolescents and adults as allergy to tree nuts can occur for the first time in adult life.

Allergy to tree nuts are outgrown in only about 10% of children, especially those with low specific IgE $< 5\text{ kU/L}$.^{50, 53}

ALLERGY TO PLANT FOOD

Allergic symptoms to various fruits and vegetables may be true allergies or cross reactivities (pollen fruit syndrome). In a recent systemic review (EuroPrevall study), the prevalence of perceived allergy to any fruits varied between 0.4-11.5%, and challenge proven food allergy to fruits was 0.1-4.3%.⁵⁴

FOOD RELATED ANAPHYLAXIS AND FATALITIES

Food allergy appears to be the most common trigger of anaphylaxis in the community. One third to half of anaphylactic episodes can be attributed to foods.^{55,56} This proportion seems to be higher in children, where food is responsible for up to 85% of anaphylactic reactions.⁵⁷ In adults, shellfish and nut are the most common triggers of food-induced anaphylaxis,⁵⁸ and in children, peanut, tree nut, milk and egg.⁵⁷

The prevalence of food-induced anaphylaxis is difficult to estimate in view of varying definitions of diagnosis of anaphylaxis and different methodologies of acquiring data. However, there is evidence that anaphylaxis is increasing⁵⁵ and, by inference, the prevalence of food-induced anaphylaxis is increasing. In the US, comparison of results in a similar geographic region from 1983-1987 and 1993 to 1997 showed a 71-100% increase in anaphylaxis.^{55,56}

Table III: Summary of Prevalence to Individual Food Allergens

Allergen	Prevalence in Young Children	Prognosis
Cow's Milk	0.3-3.5% ($< 0.5\%$ in adults)	$> 80\%$ outgrown by 16 years
Hen's Egg	0.5-8% ($< 0.5\%$ in adults)	$> 80\%$ outgrown by 16 years
Wheat	$< 1\%$	Majority outgrow- 65% by 12 years
Fish	$< 0.2\%$ (children) and $< 0.5\%$ (adults)	Usually allergic for life
Shellfish	$< 0.5\%$ (children) and $< 2.5\%$ (adults)	Usually allergic for life
Peanut	0.06-5.9%	20% outgrown
Tree Nut	0.2-1.4%	10% outgrown
Plant food	0.1-4.3%	

An Australian study which reviewed national databases for information on anaphylaxis from 1997-2005 showed an increase in food-induced anaphylaxis admissions of 350% over this period.⁵⁹ Data from Red Cross Hospital suggests a marked increase in cases seen at the allergy referral clinic with a diagnosis of anaphylaxis from 41 in 2008, to 171 in 2012 (unpublished data).

There are no studies which directly address the prevalence of food induced fatalities. By extrapolation, an estimate of 150 deaths per year in the USA due to food induced anaphylaxis has been proposed.⁶⁰ Studies from the USA, UK and Australia investigating anaphylactic deaths have revealed the following risk factors for fatal reactions:⁶⁰⁻⁶²

- Adolescents and young adults;
- Delayed use of adrenaline;
- Comorbid moderate to severe persistent asthma, and poorly controlled asthma.

FOOD ALLERGY AND CO-MORBID CONDITIONS

Food allergic patients are significantly more likely than non-allergic patients to have related atopic conditions. In patients with food allergy, studies have shown that:⁶³

- 35-71% have evidence of atopic dermatitis;
- 33-40% have evidence of allergic rhinitis;
- 34-49% have evidence of asthma.

The prevalence of IgE-mediated food allergy in patients with moderate to severe atopic dermatitis is 30-40% based on studies in Europe and US.⁶⁴⁻⁶⁷ A recently completed study on IgE-mediated food allergy in South African children, with moderate to severe atopic dermatitis at a tertiary children's hospital in Cape Town, has shown similar rates to our western counterparts, with 40% of the cohort having definite history or challenge proof of food allergy, most commonly egg allergy in 25% and peanut allergy in 24%.⁴⁸

INCREASE IN FOOD ALLERGY

Many studies have suggested a true rise in prevalence of true food allergies over the last 10-20 years⁶⁸ but further confirmation of this is required. This probable increase in food allergy requires urgent further investigation as it may be due to modifiable environmental factors.^{68,69}

American data shows that, from 2004 to 2006, there was an increase from approximately 2000 to 10 000 hospital discharges per year of children under 18 years with a diagnosis related to food allergy.⁶³ Another American study showed that the number of visits to paediatric emergency departments for food-induced anaphylaxis increased

steeply from 14.9/10 000 visits in 2001 to 38 per 10 000 visits in 2006.⁷⁰ Random telephone surveys regarding peanut and tree nut allergy in the US, using the same methodology, showed an increase in reported peanut allergy from 0.4% to 1.4% between 1997 and 2008.⁴⁶ UK data reports peanut reactivity in a cohort of 4 year old children born between 1994-1996 at 1.5%, compared to reported peanut allergy of 0.5% in a cohort born in 1989.⁷¹ Recent studies in the UK show that this increase may be levelling off.⁷²

There is no hard South African data on changes in food allergy prevalence but a general consensus amongst allergologists is that food allergy consultations are on the increase. The surprisingly high level of food allergy in both mixed race and Xhosa patients in the recent South African eczema-food allergy cohort, albeit in a high risk population, has prompted further investigation into food allergy rates in an unselected population of South African children. The concern is that South Africa may be experiencing a current increase in food allergy, and that contributing environmental factors need to be identified.

RISK FACTORS FOR FOOD ALLERGY

Below is a summary of risk factors for food allergy from population-based epidemiological studies to date.⁷³ The full implication of these risk factors and peri-natal exposure to allergens remains controversial and under active research.

1. Genetics: There is an increased risk in families of food allergy sufferers, certain HLA types and specific genes, e.g., filaggrin gene defects leading to a higher risk of eczema with food allergy.⁷³
2. Associated atopic disease: Atopic dermatitis is a major risk factor for food allergy, and asthma is a risk factor for increased severity of reactions.^{63,64}
3. Route of exposure: Exposure via the non-oral route during critical exposure periods, inhaled or via cutaneous route, may increase the risk of acquiring food allergy.
4. Timing of ingestion of allergen: Recent studies have suggested that first ingestion of food allergens during a "window" between 4 and 7 months of age may be protective.^{74,75}
5. Diet: Reduced consumption of omega 3 fatty acids may be a risk factor, as are dietary differences in food preparation, e.g., roasted peanut is more allergenic than boiled peanut.
6. Vitamin D may be protective.⁷⁶
7. Anti-acid medication may allow increased immune exposure to ingested allergens.⁷⁷
8. Hygiene hypothesis: This implies an advantage of

- diverse microbial exposure in children. Reduced risk of food allergy in rural farming areas and families with pets and more siblings increases risk with early antibiotic use and caesarean section.
9. Geographical location may affect patterns of allergen exposure and thus allergy rates, e.g., early introduction of peanut in Israel may be associated with lower peanut allergy rates.
 10. Race/ethnicity: Recent studies have suggested that non-whites may be at greater risk of food allergy, especially if they are living in a westernised environment.^{78,79} In the South African food allergy/eczema study, Black Africans had a lower allergy rate than mixed race children.⁴⁸

CONCLUSION

We find ourselves currently in the middle of a worldwide "food allergy epidemic", which may have already peaked in some countries, and certainly has made food allergy a major public health concern. Up to 10% of young children have at least one food allergy, most commonly to hen's egg, cow's milk or peanut. Severe and complex food allergies have also increased. Accordingly, a scale-up in allergy services has become a health priority in several countries. Food allergy prevalence is currently being studied in South Africa.

DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest.

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