



Accidental Reactions to Foods: Frequency, Causes, and Severity

Karina Rotella, MD¹
Roxanne C. Oriel, MD^{1,*}

Address

^{*,1}Department of Pediatrics, Division of Allergy & Immunology, Icahn School of Medicine at Mount Sinai, One Gustave L. Levy Place, Box 1198, New York, NY 10029, USA
Email: Roxanne.oriel@mssm.edu

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Abstract

Purpose of Review In this review, we present the epidemiology of food allergy and allergic reactions to foods using studies that have been published over the past decade. We review these allergic reactions — how they differ by food trigger, geographic region, demographic distribution, setting, and severity.

Recent Findings The rising prevalence of food allergy and persistent accidental allergic reactions to foods in various settings remains a worldwide concern. Differences in global prevalence, food triggers for reactions, and severity of accidental reactions may be explained by diversity in diets and food labeling legislation. A number of studies are highlighted that describe the unique challenges and risk factors that contribute to accidental reactions in restaurants and schools, as well as the efforts that have been made to improve safety and outcomes in these settings.

Summary Food allergy prevalence has demonstrated significant variations between regions and age groups. Despite best efforts by individuals, physicians, and legislative bodies to improve safety for food allergic individuals, accidental reactions to foods still occur and can result in fatalities.

Introduction

Food allergy is defined as “an adverse health effect arising from a specific immune response that occurs reproducibly on exposure to a given food,” and this

response may produce a variety of symptoms and disorders [1]. This condition is a growing worldwide concern that can be costly and life-threatening [2]. Despite

best efforts to avoid a known food allergen, accidental reactions still occur. The frequency of and causes for food allergic reactions in various parts of the world differ, in part due to differences in dietary consumption. In this review, data will be presented to offer a comparative view of these reactions. Additionally, severity

of these reactions will be discussed as it relates to the implicated food allergen, the impact of specific setting on outcomes of accidental reactions, and how food-labeling laws throughout the world are used as a first-line defense against accidental reactions.

Global Epidemiology

United States (US)

Food allergy prevalence differs by geographic region and by age group. Prevalence estimates also vary widely between survey-based studies and challenge-proven studies. In two recent survey-based studies, food allergy prevalence was estimated by considering patient-reported symptomatology to foods to determine if the history was consistent with IgE-mediated food allergy. Through this method, food allergy prevalence was reported to be as high as 8% in children and adolescents [3], and 10.8% in US adults [2]. The most common food allergens among children and adolescents were peanut (2.2%), milk (1.9%), shellfish (1.3%), tree nuts (1.2%), and egg (0.9%) although these differ by age [4]. Cow's milk is the most common food allergen in early life, then the others become more prevalent among school-aged children and adolescents [4]. Adults may experience persistent food allergies from their childhood or may have adult-onset food allergies, reported in about half of US food-allergic adults with the most common new-onset allergy to shellfish. The five most common food allergies reported overall among US adults were shellfish (2.9%), peanut (1.9%), milk (1.8%), tree nuts (1.2%), and finned fish (0.9%) [2].

A history of at least one "severe" reaction, characterized by symptoms across multiple organ systems, was reported in 42.3% of US food-allergic children [4] and 51.1% of US food-allergic adults [2]. In both adults and children, severe reactions were most often attributed to peanut and tree nuts [2, 4]. Of food-allergic adults, 38% reported at least one lifetime ED visit related to food allergy [2]. A population-based real-world study using a US health care claims database consisting of peanut-allergic children aged 4 to 17 years showed that the annual incidence of peanut allergy might be increasing (claims dated from January 2011 to December 2017). Other notable findings include one severe reaction to peanut in 55.5% and multiple severe reactions to peanut in 32.2% [5].

Europe

A recent systematic review looking at global patterns in food-induced anaphylaxis reported estimated prevalence of allergy to specific foods broken down by region. The estimated food allergy prevalence in European children was

highest for peanut (0.42%), cow's milk (0.35%), hen's egg (0.32%), hazelnut (0.28%), wheat (0.16%), walnut (0.12%), and shellfish (0.11%). For European adults, the highest prevalence was for hazelnut (0.86%), shellfish (0.41%), peanut (0.35%), walnut (0.3%), cow's milk (0.16%), fish (0.14%), and hen's egg (0.08%) [6]. The European countries included in these estimates were Switzerland, Spain, Greece, Bulgaria, Poland, Lithuania, Iceland, and The Netherlands. There were also high prevalence rates observed for several fresh fruits and vegetables such as peach, kiwi, apple, and carrot, likely due to the high prevalence of birch pollen sensitization in this region [6]. Among school-aged children specifically, the EuroPrevall birth cohort included infants in eight European countries (Iceland, UK, the Netherlands, Germany, Poland, Lithuania, Spain, and Greece) which were followed to school-age (6–10 years old). They found the estimated school-age food allergy prevalence to be between 1.4 and 3.8%, confirmed by double-blind, placebo-controlled oral food challenges [7].

Another systematic review looking at the epidemiology of anaphylaxis in Europe reported that the proportions of food allergic reactions that resulted in anaphylaxis varied widely, with estimates ranging from 0.4 to 39.9%. The food triggers most commonly resulting in anaphylaxis in children were cow's milk (29%), egg (25%), and in 5% or less for each of the following: hazelnut, peanut, kiwi, walnut, pine nut, fish, wheat, soy, shrimp, apricot, and sesame [8]. In the UK specifically, a study examined changes in the epidemiology of food-induced anaphylaxis over a 20-year period (1998 to 2018). They demonstrated an overall increase in hospital admissions due to food-induced anaphylaxis with the greatest increase seen in children younger than 15 (an increase of 339%). Despite the increases seen in hospitalizations, case fatality rate due to food-induced anaphylaxis dropped from 0.70% in 1998 to 0.19% (confirmed fatal food anaphylaxis) or 0.30% (suspected fatal food anaphylaxis). The highest rates of fatal food anaphylaxis were seen in teenagers and persisted into mid-adulthood. In over a quarter of cases of fatal food anaphylaxis at all ages, a specific trigger could not be determined. Of the triggers that were identified, cow's milk was responsible for 26% of deaths in children and 5% in adults. At least 46% of deaths across both age groups were attributed to peanut or tree nuts [9].

Australia

The Melbourne HealthNuts and SchoolNuts studies are large population-based studies with challenge-confirmed food allergies. In the cohort of infants challenged at age 1, prevalence of food allergy was 11%, though when followed to 4 years of age, prevalence decreased to 3.8% [10]. In older children and young adolescents (10 to 14 years of age), there was an overall food allergy prevalence of 4.5–5.5%, with peanut and tree nuts as the most common triggers [11]. Regarding food-induced reactions, a review of a national database of fatalities due to food-induced anaphylaxis revealed that the majority were due to shellfish (45%), with peanut and tree nuts noted as the other top triggers (18% and 9%, respectively) [12].

Asia

The most common food allergy reported among adults in Asia (Taiwan and India) is cow's milk (0.48%), followed closely by peanut (0.46%), then hen's egg (0.3%), shellfish (0.27%), finned fish (0.22%), and wheat (0.14%). For children in India, China, Russia, Thailand, Japan, and Korea, shellfish was the most prevalent at 0.55%, followed by fish (0.29%), peanut (0.21%), hen's egg (0.18%), buckwheat (0.16%), tree nuts (0.12%), and cow's milk (0.07%) [6]. There is significant global variation in common triggers of food allergy due to diverse diets. Unique food triggers in Asia include buckwheat, especially in South Korea and Japan where buckwheat noodles are commonly consumed, as well as swiftlet bird's nests, a delicacy in Singapore and Malaysia [13].

Africa

There is a relative scarcity of data for most countries in Africa, though studies from Morocco and South Africa have shown peanut, tree nuts, hen's egg and cow's milk to be the most frequent causes for food-induced anaphylaxis [6]. A cross-sectional study of urban and rural South African toddlers (12 to 36 months) revealed an overall prevalence of food allergy to be 2.5% in urban toddlers, compared with 0.5% in rural toddlers. Among urban children, the prevalence was highest for raw egg white (1.9%), cooked egg (0.8%), peanut (0.8%), cow's milk (0.1%), and fish (0.1%) [14].

Latin America

Common food allergens reported to cause anaphylaxis in Latin America (Argentina, Brazil, Chile, Mexico, Venezuela) include cow's milk, hen's egg, shellfish, and fish, with relative lower prevalence of peanut as a cause of food anaphylaxis [6].

Severity in Special Populations

In addition to geographic and age-related differences in the prevalence of food allergy, the management of food allergies also differs greatly for individuals at different ages and life stages which can impact the frequency of accidental ingestions [1]. For example, it has been found that adolescent patients may have more severe reactions compared to their younger pediatric counterparts, potentially due to more risk-taking behavior [1, 15, 16]. A Canadian survey-based study found that peanut-allergic teenagers and youth living with a single parent had higher risk of accidental allergen exposure [17]. Cross-sectional surveys in Australian and US adolescents report high rates of failing to carry their epinephrine, not informing others of their allergy, and ingesting foods that are potentially risky [16, 18].

Another study using an online cross-sectional survey distributed to parents of food-allergic children and adolescents in the UK, South Africa, Australia, and the USA, compared reported accidental ingestions (AIs). Many of the reactions were shown to occur prior to age 12, with 85% of adolescents reporting an accidental ingestion versus 70% of children. Adolescents reported fewer severe reactions (2% versus 16%), though twice as many required epinephrine administered by a health professional for their most severe reaction compared with children. The number of reactions was, on average, 27% lower in the USA compared with the UK [19].

Location of Accidental Reactions

One recent US study has shown that the most common location for reactions in both children and adults were at home (44%), followed by restaurants (21%), school (in 6% of children), and the workplace (11% of adults) [20]. Although most accidental reactions happen in one's home, there are unique challenges faced when reactions occur elsewhere — in other's homes, restaurants, school, during travel, and in other public places.

Home

Food allergen avoidance is one effective way to prevent severe allergic reactions but can be difficult and restrictive for food allergic individuals and their families. If chosen as the management strategy, ingredient labeling of products must be reviewed carefully by individuals and their families. The US Federal Government has passed several laws and regulations to protect food-allergic individuals, including the 2004 Food Allergen Labeling and Consumer Protection Act (FALCPA), which mandates food manufacturers to list any of the 8 major allergens on food labels (milk, egg, soy, wheat, peanut, tree nuts, fish, and crustacean shellfish) [21, 22]. Sesame will be added to the list of major food allergens that must be disclosed on labels, effective January 2023 as part of the Food Allergy Safety, Treatment, Education, and Research (FASTER) Act [22]. Similar legislation was passed in Europe in 2014 (European Union Regulation 1169/2011) whereby the presence of 14 ingredients that can cause allergy or intolerance must be listed on food labels of prepackaged foods and available for unpacked foods. These top allergens include milk, egg, cereals (containing gluten), lupine, soy, peanut, tree nuts, fish, sesame and mustard seeds, crustaceans, mollusks, celery and celeriac, and sulfur dioxide and sulfites [23]. On a global scale, The Codex Alimentarius was established by the Agricultural Association of the United Nations and the World Health Organization to facilitate the safety of global trade of food through a set of international food standards, guidelines, and codes of practice. The Codex requires ingredient disclosure for 8 food groups which are considered to cause over 90% of food-induced allergic reactions: gluten, crustaceans, egg, fish, peanut and soybean, milk, tree nuts, and sulfites [6].

Despite labeling laws, food allergens can inadvertently be present in a food because of cross-contamination or cross-contact. “Precautionary Allergen Labeling” (PAL) or “advisory labeling” is used in cases when absence of the allergen cannot be guaranteed, using statements such as “may contain X,” or “processed in a facility that manufactures X.” These advisory labels are voluntary and have been found to appear in 17% of manufactured items in the USA and in 65% of products in Australia [24, 25] though the presence or absence of the advisory labels does not correlate with the presence or absence of detectable protein [26]. Purchasing habits by food-allergic consumers varied based on the way the PAL was worded, and despite a PAL being on a product, up to 40% of surveyed consumers purchased products with a PAL anyway [27]. The inconsistencies in advisory labeling and varying amounts of detectable protein may lead to confusion for food-allergic individuals when reading PAL, resulting in potential increased consumption of food allergens and subsequent accidental reactions.

A longitudinal prospective cohort study from the Netherlands collected data on frequency, causes, severity, and consequences of accidental allergic reactions on 157 adults with food allergy. These patients used a secured internet portal to report details of their accidental reactions over a period of 1 year. If available, patients could also provide a sample of the product or label to be analyzed. The mean number of accidental reactions was approximately 1 per person per year, and patients were able to attribute their reaction to a specific product in 78% of reported cases. Of food products that were sent in to be analyzed by ELISA, 37% contained non-ingredient allergens with cow’s milk, peanut, and hazelnut being detected most often. More than half of these products did not have a PAL statement which indicated that accidental reactions may occur either due to absence of a PAL statement or patients disregarding the PAL statement that is present on a product [28]. Of those that did not read the label, the reasons were either “label was illegible” that they “consumed the product before” and other reasons such as “I didn’t expect allergens in the product”/ “thought it was safe” [29].

In 2007, in Australia and New Zealand, the Voluntary Incidental Trace Allergen Labeling (VITAL) program was introduced. This program was developed to provide guidance to food manufacturers regarding consistent and appropriate precautionary food labeling. The most recent version included an updated review of data from low-dose oral food challenges to determine reference doses, which are the protein levels of allergenic foods below which only the most sensitive food-allergic individuals would experience an allergic reaction. These reference doses inform the “Action Levels,” or concentrations of cross contact allergen proteins that would need to be reported as a PAL on packaged goods [30]. This approach aims to avoid indiscriminate use of PAL and ensure that manufactured food is safe to consume for the vast majority of food-allergic individuals. To our knowledge, there is no data regarding changes in rates of accidental reactions since implementing the VITAL program, but future studies on this could inform better precautionary food labeling practices for other countries.

Restaurants and Other Food Establishments

Dining out at restaurants and take-out account for a large proportion of severe accidental reactions. Due to fears of accidental exposure, many food-allergic patients may avoid dining out entirely [31].

A study was conducted to focus on peanut and tree nut allergic reactions in restaurants using a structured questionnaire administered to registrants of the US Peanut and Tree Nut Allergy Registry (PAR). Of these respondents, 13.7% reported reactions associated with restaurants or other food establishments. Most reactions were caused by peanut (67%) or tree nuts (24%), and desserts were a common cause (43%). Establishments commonly cited by the subjects as location for the allergic reaction included Asian food restaurants (19%), ice cream shops (14%), and bakeries/doughnut shops (13%). Of those that had a previously diagnosed allergy, only 45% notified the restaurant staff of the allergy, and in half of these cases, the food allergen was hidden (e.g., in sauces, dressings, etc.), which prevented visual identification of the peanut or tree nuts. In 22% of cases, exposures were likely due to contamination of shared cooking/serving supplies [32].

In a 2007 survey conducted at the Food Allergy and Anaphylaxis Network conference surveying parents of food-allergic children, 34% of respondents reported at least one food allergic reaction occurring in a restaurant, and 36% of those reported at least 3 reactions in restaurants. Of the total reactions, 70% were to peanut, and 64% were to tree nuts [31].

In a more recent study, using the Food Allergy Research and Education (FARE) registry, self-reported data from 2822 individuals were collected over a 2-year period. Dining out accounted for the second most common location for a reaction for both children and adults at 21%, after one's home (44%). Many were severe with 28% requiring 1 dose and 6.2% requiring 2 doses of epinephrine. Peanut, tree nuts, and milk were the most common culprits, and tree nuts resulted in the most use of epinephrine. The types of restaurants where reactions occurred differed between children and adults; however, cafes, fast food restaurants, and Asian restaurants were among the most common for both groups. The most common food allergens that caused a reaction while dining out for both children and adults were peanut, tree nuts, and milk. Biphasic reactions were reported in 14.4% of cases. Of those that used epinephrine, 16.3% reported hospitalization, 4.2% reported ICU admission, and no deaths in this cohort [20]. Allergic reactions may also occur with ingestion of takeout food from restaurants, with 16.8% of food-allergic individuals reporting allergic reactions from takeout food. Precautions were taken by the individuals and families which included writing the allergy in an online order, calling the restaurant to discuss the order, and visually inspecting the dish, though accidental reactions still occurred [33].

Fatal food reactions have also been reported with restaurants, take-out, catering, or some other food establishment. A registry of fatal food reactions showed 18 of 63 (28%) of fatalities occurring in association with a food establishment in the USA [34], compared with 16 of 48 (33%) in the UK [35].

Several factors increase the risk of a food-allergic reaction in restaurants including errors such as miscommunication between patron and restaurant staff, failure to disclose a food allergy, cross-contamination with allergen,

hidden or undisclosed allergenic ingredients, and inconsistent or incomplete food labeling [32]. As such, preventing food-allergic reactions in restaurants must occur at many levels and involve practitioners, patients, restaurants, and legislative action by governments. Practitioners should feel comfortable discussing these issues with their patients as part of anticipatory guidance and should be counseled that prevention of accidental ingestion in a food establishment first and foremost requires clear communication with restaurant staff. The patron must clearly identify themselves or their affected children as food-allergic and should be encouraged to call ahead to state their allergies. The patron can provide written materials explaining their allergies to those that will be preparing their food, such as a “chef card” or “allergy card” including information about cross-contamination. Patients should also be prepared with an Anaphylaxis Emergency Care Plan and epinephrine auto-injectors [36].

As discussed, food ingredient labeling remains the first line against allergic reactions and is mandated on products through legislation. The restaurant industry follows The Food and Drug Administration’s (FDA) Food Code, with its most recent iteration from 2017. The Food Code recommends that the manager of the establishment be knowledgeable about food allergies and is also responsible for training employees in food safety, including awareness of food allergies [37]. Some studies have shown that chain or franchise restaurants may be more likely to provide food allergy training to staff than independently-owned food establishments [38]. Barriers to adequate food allergy training for staff include time constraints, a negative attitude among food preparers, high cost of training, high labor turnover, lack of interest, and difficulty implementing training in multiple languages spoken by restaurant staff [36]. Moreover, advocacy efforts to decrease allergic reactions in restaurants have likely been delayed due to the ongoing COVID-19 pandemic which have greatly impacted the restaurant industry.

Despite the FDA Food Code recommendations, the CDC’s 2017 MMWR indicated that employee training might not be occurring. The CDC’s Environmental Health Specialists Network (EHS-Net), a collaborative forum of federal agencies and state and local health departments with six sites, interviewed personnel at 278 restaurants to learn more about food allergy training. Less than half of the restaurant managers (44.4%), food workers (40.8%), and servers (33.3%) reported receiving food allergy training, and approximately one-fourth of surveyed managers reported having no ingredient lists for menu items. Few restaurants had dedicated equipment for preparing allergen-free food [39].

Schools and Child Care Facilities

There is increasing literature to support the rising prevalence of food allergy in infants, children, and adolescents. Studies have shown that among food-allergic school-aged children, 16–18% have experienced an allergic reaction in school [40, 41], with 15% treated with epinephrine [40]. In one report, 46% of anaphylactic reactions occurred in the classroom, 17% in the health office, 10% on playgrounds, and only 9% occurred in the cafeteria [42]. Younger children

had reactions more frequently, with 64% in day care or preschool, compared with 36% in elementary school or higher grades [41]. Young children with food allergies are presented with unique challenges due to their tendency to place objects and their own hands into their mouths, allowing potential transfer of allergens [43]. To remove food allergens from cleaning surfaces, hands, and toys, soap and water, household cleaner, or cleaning wipes must be used, whereas water alone or antibacterial hand sanitizer do not effectively remove the allergen [43]. The most commonly implicated foods causing allergic reactions in schools included milk (32%) and peanut (29%) [40]. Not only can accidental reactions occur by ingestion, skin contact (for example, peanut butter craft projects), or possible inhalation (by cooking) also accounted for some reactions among schoolchildren with peanut and tree nut allergies [41]. When reactions did occur, treatment delays were attributed to delayed reaction recognition, calling parents instead of treating reaction, not following emergency action plans, and unsuccessful attempts at administering epinephrine autoinjectors [41].

Food allergy safety in schools requires collaboration between families, healthcare practitioners (the allergist and pediatrician), and school personnel. Food labels at schools should be carefully reviewed before serving to food-allergic children. In order to minimize allergen exposures for students with food allergy, some schools have implemented policies such as school-wide bans on allergens or food-specific restrictions like designated nut-free classrooms and lunch tables [43]. The rate of allergic reactions has actually been shown to be comparable or even increased in schools with specific bans on common food allergens [17, 40, 43], potentially resulting in a “false sense of security” when students enroll in a nut-free school [43]. It is important to note that harassment or bullying of students because of their food allergy may occur, and care must be taken not to completely ostracize the child with food allergies and separate them from their friends [44].

Resources for managing food allergies in schools include the 2013 Centers for Disease Control and Prevention (CDC) Voluntary Guidelines [45], and the 2014 guidelines published by the European Academy of Allergy and Clinical Immunology [46]. These guidelines recommend training school personnel to develop personalized plans for food-allergic children and how to recognize and treat allergic reactions. A school stock of unassigned epinephrine autoinjectors may also be helpful for treatment of first-time food allergic reactions, which have been shown to occur in up to 24% of children experiencing anaphylaxis at school [42]. The availability of unassigned stock epinephrine and providing training to non-nursing staff members are measures that may prevent treatment delay and potentially save lives [47]. Individualized Health Care Plans (IHPs) including the Emergency Action Plan (EAP) should be created as a collaboration between the family, physician, and school nurse, with input from other school personnel, and can be tailored to a particular child’s age and development level [44].

In the Care of Other Guardians

For children, the parent is usually responsible for recognizing and treating an accidental reaction, though sometimes these may occur under the supervision of another guardian, such as a nanny. A study using an online survey assessed

153 nannies. Data was collected on knowledge, attitude, and management of food allergies in children. Of the nannies surveyed, 37% reported caring for a child with food allergy, and of these, 71% reported training on administering epinephrine, though many were concerned about discomfort with carrying out this procedure. Other gaps in knowledge included believing that a child could safely eat a small amount of allergenic food, and the possibility of diluting the food to reduce an allergic reaction [48].

Conclusion

Despite increased focus on food allergy awareness, research, and legislation, severe food-allergic reactions and even fatalities remain a worldwide concern. These accidental reactions have been shown to vary by setting and region, with distinct challenges faced by food-allergic individuals in restaurants and schools. Prevention of such reactions requires interventions at several levels, beginning with proper counseling of patients and their families by health practitioners. Future directions will also include further research into food allergy treatments such as oral immunotherapy and biologics which may become an additional line of defense against accidental reactions.

Compliance with Ethical Standards

Conflict of Interest

The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent

This article does not contain any studies with human or animal subjects performed by any of the authors.

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