

*Original article***Accidental ingestions in children with peanut allergy**

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**Background:** Accidental exposure to peanut has been reported to occur frequently. Total avoidance of peanut is difficult because of its widespread use, manufacturing and labeling errors, utensil contamination, and label misinterpretation.

**Objective:** Given the apparent increased awareness of peanut allergy by both consumers and food manufacturers, we aimed to determine the current frequency of accidental exposures occurring in peanut allergic children in Quebec and to identify factors associated with exposure.

**Methods:** The parents of children with peanut allergy diagnosed at the Montreal Children's Hospital completed questionnaires about accidental exposure to peanut occurring over the period of the preceding year. Logistic regression was used to identify associated factors.

**Results:** Of 252 children, 62% were boys, with a mean age of 8.1 years (SD, 2.9). The mean age at diagnosis was 2.0 years (SD, 2.1). Thirty-five accidental exposures occurred in 29 children over a period of 244 patient-years, yielding an annual incidence rate of 14.3% (95% CI, 10.0% to 19.9%). Fifteen reactions were mild, 16 moderate, and 4 severe. Of 20 reactions that were moderate to severe, only 4 received epinephrine. Eighty percent of children attended schools prohibiting peanut, and only 1 accidental exposure occurred at school. No associated factors were identified.

**Conclusion:** Accidental exposure to peanut occurs at a lower frequency than previously reported, but most reactions are managed inappropriately.

**Clinical implications:** Enhanced awareness, access to safer environments, and good food manufacturing practices may have contributed to a lower incidence of inadvertent peanut exposure, but a further reduction and better education on allergy management are desirable. (*J Allergy Clin Immunol* ■■■■;■■■;■■■-■■■.)

**Key words:** Peanut allergy, accidental ingestion, treatment, peanut safe policies

Peanut allergy is a serious and potentially life-threatening condition,<sup>1</sup> accounting for the majority of severe anaphylactic reactions to foods.<sup>2</sup> Unlike milk and egg allergies, which typically resolve during early childhood, peanut allergy tends to persist throughout life.<sup>2-4</sup> Although tolerance to peanut can develop, only the minority of children outgrow this food allergy; thus, most children with peanut allergy remain allergic indefinitely and carry the risk of anaphylaxis throughout their lives.<sup>5-8</sup> In addition to the serious nature of peanut allergy, anecdotal evidence and 2 longitudinal studies suggest its prevalence is increasing,<sup>9,10</sup> with current literature estimating that 0.8% to 1.5% of North American and British children are affected.<sup>9-12</sup>

Thus, given the lifelong persistence of peanut allergy and the anticipated increase in its prevalence, the potential for accidental exposure is an important concern.<sup>13-15</sup> The ubiquitous nature of peanut in the food industry can make dietary avoidance difficult, and the sharing of food by children, cross-contamination of foods and utensils, incorrect ingredient information in restaurants and on product labels, and mistakes in label reading further contribute to the risk of inadvertent exposure. In 1989, an American study<sup>7</sup> reported that 50% of known children with peanut allergy had an inadvertent exposure in the preceding year, and 75% had an inadvertent peanut exposure in the preceding 5 years. Subsequently, a more recent American study reported that 55% of children with peanut allergy had an accidental exposure over a period of 5.4 years,<sup>16</sup> whereas another found an annual incidence rate of 33%.<sup>17</sup> A British study published in 2005 reported an annual incidence rate of 55% in children allergic to peanut and/or nuts before implementation of an allergy management plan and 7% postimplementation.<sup>18</sup>

No estimate of the rate of accidental exposure to peanut exists for Canadian children with peanut allergy. Although peanut consumption is anticipated to be similar in Canada and the United States, Canadian schools have been tremendously proactive in designing and implementing peanut-safe policies for students,<sup>19</sup> and Canadian labeling regulations for food allergens are amongst the strictest internationally.<sup>20-22</sup> Thus, we sought to determine the accidental exposure rate to peanut in children with peanut

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Abbreviation used  
SPT: Skin prick test

allergy living in the greater Montreal area and to identify determinants of these inadvertent exposures.

## METHODS

### Patient selection

Children  $\geq 4$  years of age were invited to participate if they were diagnosed with peanut allergy at the Montreal Children's Hospital Allergy Clinic between January 2000 and February 2005. Children  $< 4$  years were excluded because we also administered a quality of life questionnaire that was inappropriate for younger children. The study was approved by the Research Ethics Board of the McGill University Health Centre.

The medical charts were reviewed to confirm eligibility criteria, as well as demographic information, atopic history, family history, details of the initial and most severe accidental reaction to peanut (if applicable), number of previous accidental reactions, and previous use of epinephrine.

The age at diagnosis was either the age at which the child had his/her first allergic reaction to peanut or, in the case of children who had never been exposed to peanut, the age at which the diagnosis was made by a physician after confirmatory diagnostic testing. An accidental exposure was defined as any allergic reaction to peanut occurring after the child was diagnosed as allergic to peanut. For the purposes of determining rate of accidental exposure, children were considered to be allergic to peanut immediately after their first reaction and before they underwent confirmatory diagnostic testing. We felt it was likely that most families assumed their children were allergic after the first reaction and attempted to avoid peanut after this experience. However, only children who then had confirmatory testing performed and fulfilled the diagnostic criteria were considered eligible for the study. Sixty-one percent of children who had at least 1 allergic reaction to peanut had their confirmatory testing performed within 1 year of the initial reaction, whereas the remainder had it performed later. Thus, all children included in our study met eligibility criteria for peanut allergy, but some had a delay in diagnosis confirmation of  $> 1$  year.

### Establishing the diagnosis of peanut allergy

Children were eligible for study enrollment if either of the following criteria were fulfilled: (1) the child had a convincing history of an allergic reaction to peanut and a positive skin prick test (SPT) to peanut or a peanut specific IgE level  $\geq 0.35$  kU/L, or (2) the child had no history of peanut ingestion or an uncertain clinical history of a peanut allergy and either a positive SPT and a peanut specific IgE level  $\geq 15$  kU/L or a positive SPT and positive food challenge with peanut.

### Clinical history

A convincing history of a peanut allergy was defined as a minimum of 2 mild symptoms or signs or either 1 moderate or 1 severe symptom or sign occurring within 60 minutes after peanut contact or ingestion. The severity of the reaction was defined as follows:

- (1) Mild: pruritus, urticaria, flushing, and/or rhinoconjunctivitis
- (2) Moderate: angioedema, change in voice, coughing, nausea and/or vomiting, and/or abdominal pain

- (3) Severe: wheezing, stridor, cyanosis, and/or circulatory collapse<sup>23</sup>

### Diagnostic tests

**Skin prick test to peanut protein.** A SPT was defined as positive if the greatest diameter of the wheal was at least 3 mm greater than the negative control (saline) at the time of the child's initial evaluation for peanut allergy.<sup>24</sup>

**Peanut specific IgE level.** The serum level of peanut specific IgE was measured by the CAP-system Fluoroenzyme Immunoassay (Pharmacia Diagnostics, Uppsala, Sweden). As reported in the literature, a patient with a peanut specific IgE level  $\geq 15$  kU/L has at least a 95% likelihood of developing an allergic reaction to peanut on exposure.<sup>25-28</sup> Thus, we defined patients who had never been exposed to peanut or had an uncertain clinical history with a peanut specific IgE level  $\geq 15$  kU/L as allergic to peanut without performing a challenge. Patients with a convincing clinical history of an allergic reaction to peanut and a peanut specific IgE  $\geq 0.35$  kU/L were also defined as allergic because, in clinical practice, the risk of these children reacting on peanut exposure is believed to be so high that a challenge is seldom performed.<sup>29</sup>

**Oral food challenges to peanut.** Oral food challenges to peanut were conducted in our hospital according to previously published protocols.<sup>30,31</sup> Either open or single-blind food challenges were performed at the discretion of the treating physician on the basis of the available clinical history. Oral food challenges were considered negative if a child ingested at least 2500 mg peanut followed by an open ingestion of a typical peanut butter serving (ie, 1-2 packets of peanut butter on crackers). Oral food challenges were considered positive if at least 2 mild or either 1 moderate or 1 severe allergic symptom or sign occurred.<sup>30,31</sup>

### Participant questionnaires

Eligible participants with peanut allergy were invited to complete a questionnaire. Informed consent was obtained from the parent and/or child. French questionnaires were developed by translation and back-translation. Reminders were sent out to families who had not returned the questionnaire within 2 weeks of the mailing. Parents were queried on demographics, the child's comorbid medical illnesses and personal history of atopy, duration of breast-feeding, and frequency and characteristics of any accidental exposure to peanut over the preceding year. Details of the accidental peanut exposure requested were age of child, quantity and type of foods ingested, location (home, school, restaurant, and so forth) of ingestion, allergic symptoms, onset and duration of reaction, and treatment administered.

### Statistical analysis

Descriptive statistics such as means, ranges, and SDs were compiled for all continuous variables. The annual incidence rate of accidental exposures was expressed as the number of events divided by the sum of the patient-years at risk. All patients were included in this calculation whether or not they provided a full year of observation. To be consistent with published literature, the annual rate of accidental exposure was also calculated as the proportion of patients who had at least 1 accidental exposure among all those patients who provided a full year of observation. Univariate and multivariate logistic regression analyses were used to estimate the associations between child and parental characteristics and risk for an accidental exposure to peanut. Odds ratios and 95% CIs were calculated for each potential independent variable. Patient characteristics evaluated as possible risk factors included the age of the child; duration of peanut allergy; sex; ethnic background; atopic conditions such as eczema, asthma, rhinitis, or other food allergies; attending a school/daycare permitting peanut; and other comorbid health conditions. Personal

**TABLE I.** Characteristics of participants and nonparticipants

|                                                         | Participants, n = 252 | Nonparticipants, n = 185 |
|---------------------------------------------------------|-----------------------|--------------------------|
| Age, y                                                  |                       |                          |
| Mean (SD) [CI]                                          | 8.1 (2.9) [7.7, 8.5]  | 8.7 (3.3) [8.2, 9.2]     |
| Range                                                   | 4, 17                 | 3, 17                    |
| Age at diagnosis, y (SD) [CI]                           | 2.0 (2.1) [1.8, 2.3]  | 4.2 (3.7) [3.7, 4.8]     |
| Disease duration, y (SD)                                | 6.1 (3.2) [5.7, 6.5]  | 4.5 (3.4) [4.0, 5.0]     |
| Age at first accidental exposure over past year, y (SD) | 7.8 (3.7)             | N/A                      |
| Sex, % boys [CI]                                        | 61.9% [55.6, 67.9]    | 59.5% [52.0, 66.6]       |
| Ethnic background of child, % white                     | 90.9%                 | N/A                      |
| Personal atopic history, % [CI]                         | n = 222               | n = 173                  |
| Atopic dermatitis                                       | 41.4% [34.9, 48.2]    | 54.9% [47.2, 62.5]       |
| Asthma                                                  | 57.7% [50.9, 64.2]    | 59.5% [51.8, 66.9]       |
| Allergic rhinitis                                       | 2.7% [1.0, 5.8]       | 1.7% [0.4, 5.0]          |
| Other food allergies                                    | 45.5% [38.8, 52.3]    | 52.6% [44.9, 60.2]       |
| At least 1 atopic comorbidity                           | 83.3% [77.8, 88.0]    | 88.4% [82.7, 92.8]       |
| Nonatopic comorbidity, % [CI]                           | 43.3% [37.0, 49.6]    | N/A                      |
| Family atopic history, %, [CI]                          | n = 222               | n = 173                  |
| Atopic dermatitis                                       | 18.0% [13.2, 23.7]    | 19.1% [13.5, 25.7]       |
| Asthma                                                  | 23.9% [18.4, 30.0]    | 31.2% [24.4, 38.7]       |
| Allergic rhinitis                                       | 8.1% [4.9, 12.5]      | 6.9% [3.6, 11.8]         |
| Other food allergies                                    | 12.6% [8.5, 17.7]     | 12.1% [7.7, 18.0]        |
| At least 1 atopic comorbidity                           | 47.3% [40.6, 54.1]    | 47.4% [39.8, 55.1]       |
| Breast-feeding, %                                       |                       |                          |
| Feeding practices                                       |                       |                          |
| Formula only                                            | 21.5%                 | N/A                      |
| Breast-feeding only                                     | 27.9%                 | N/A                      |
| Both                                                    | 50.6%                 | N/A                      |
| Duration                                                |                       |                          |
| <1 mo                                                   | 6.6%                  | N/A                      |
| 1-3 mo                                                  | 18.7%                 | N/A                      |
| 4-6 mo                                                  | 28.8%                 | N/A                      |
| >6 mo                                                   | 46.0%                 | N/A                      |
| Peanut avoidance during lactation                       | 17.5%                 | N/A                      |
| Initial reaction to peanut, % [CI]                      | n = 252               | n = 185                  |
| No reaction                                             | 14.3% [10.2, 19.2]    | 13.5% [8.9, 19.3]        |
| Mild reaction                                           | 31.0% [25.3, 37.1]    | 28.6% [22.3, 35.7]       |
| Moderate reaction                                       | 43.3% [37.0, 49.6]    | 41.1% [33.9, 48.5]       |
| Severe reaction                                         | 11.5% [7.8, 16.1]     | 16.2% [11.2, 22.3]       |
| Attending school permitting peanuts, %                  | 20.2%                 | N/A                      |
| Age of parents                                          |                       |                          |
| Mother, y (SD)                                          | 39.5 (5.4)            | N/A                      |
| Father, y (SD)                                          | 41.5 (6.0)            | N/A                      |
| Parental education and work status, %                   | Mother Father         |                          |
| Completed high school                                   | 16.0% 20.3%           | N/A                      |
| Completed college education                             | 22.3% 17.5%           | N/A                      |
| Completed university education                          | 60.8% 58.9%           | N/A                      |
| Currently employed                                      | 65.9% 87.3%           | N/A                      |

N/A, Data not available.

peanut allergy history including number of past reactions, skin test wheal diameter at diagnosis, severity of worst past reaction, and use of epinephrine for any previous reaction were also used as predictors. Parental characteristics included age, level of education, employment, and marital status.

## RESULTS

### Patient characteristics

Four hundred thirty-seven children with peanut allergy were identified and were administered a questionnaire. Two hundred fifty-two responded, yielding an overall response rate of 57.7%. The participants were

predominantly white boys (61.9), with a mean age of 8.1 years (range, 4-17 years; [Table I](#)). The mean age (SD) of diagnosis and at the time of the first accidental exposure over the preceding year were 2.0 (2.1) and 7.8 (3.7) years, respectively. The children had a mean duration of peanut allergy of 6.1 (3.2) years. The majority of children were atopic (83.3%), and 78.5% of children were breast-fed (58.7% of mothers breast-fed for >3 months). Twenty percent of children attended schools permitting peanut. Most parents were in their early 40s, completed a university degree, and were currently employed.

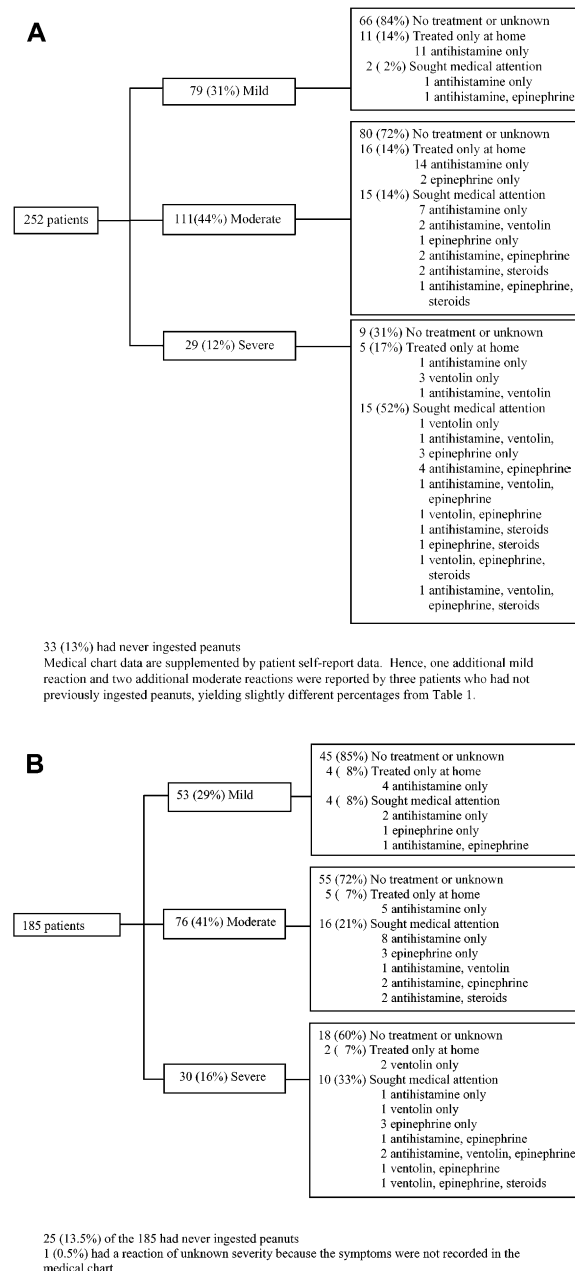


**FIG 1. A,** Characteristics and management of initial reaction to peanuts for participants. **B,** Characteristics and management of initial reaction to peanuts for nonparticipants.

Nonparticipants were similar to participants in terms of percent boys, characteristics of initial reaction to peanut, and personal and family history of atopy (Table I). However, nonparticipants were slightly older, had been diagnosed later, and had shorter disease duration.

### Initial reaction to peanut

Of 252 participants, 75% of children with peanut allergy initially had an allergic reaction classified as mild to moderate (Fig 1, A). Thirteen percent had never been exposed to peanut at the time of diagnosis, but were

considered allergic to peanut on the basis of confirmatory diagnostic testing. Most children (84%) with a mild reaction did not receive any treatment (either from a parent/caregiver or health professional) or the treatment was not specified. Eleven of the 79 mild reactions were treated only at home, and professional help was not sought; medical attention was sought for only 2 reactions. Of the children with an initial moderate to severe reaction, only 5% with a moderate reaction and 41% with a severe reaction received epinephrine. Only 15 of the 111 moderate reactions and 15 of the 29 severe reactions sought medical

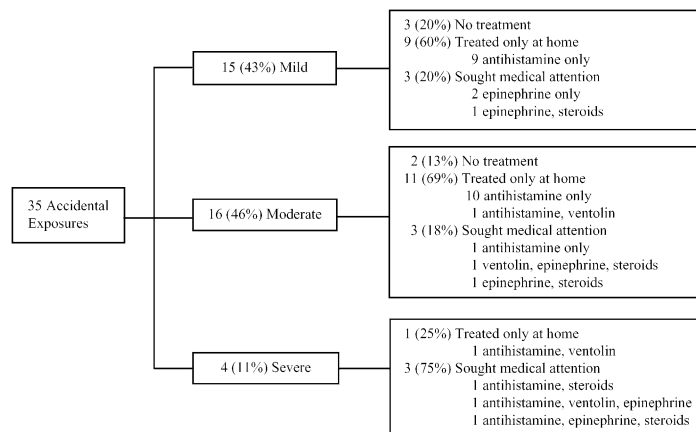


FIG 2. Characteristics and management of accidental exposure to peanuts.

attention. Of the 185 nonparticipants, 70% had an initial allergic reaction classified as mild to moderate (Fig 1, B), 16% were classified as severe, and 13.5% had never been exposed to peanut. One patient could not be classified because symptoms were not recorded in the chart. Eighty-five percent of nonparticipants with a mild reaction did not receive medical treatment or the treatment was not specified, and 4 of 53 were treated only at home. Seven percent with a moderate and 27% with a severe reaction received epinephrine and 16 of 76 of the moderate and 10 of 30 of the severe sought medical attention.

### Accidental exposure to peanut

Thirty-five accidental exposures to peanut occurred in 29 children over a period of 244 patient-years, yielding an annual incidence rate of 14.3% (95% CI, 10.0% to 19.9%). When only children who were observed for a full year were considered, the annual rate of accidental exposure was 9.7% (95% CI, 6.3% to 14.2%; 23 children among the 237 observed for 1 year having at least 1 accidental exposure).

Thirty-one (89%) accidental exposures were of mild to moderate severity (Fig 2). Of the 15 mild reactions, 2 were treated with epinephrine and 1 with epinephrine and steroids. Nine of the 15 reactions were treated only at home. Of the 16 moderate and 4 severe reactions, only 2 moderate and 2 severe reactions were treated with epinephrine. Eleven of the 16 moderate and 1 of the 4 severe reactions were treated only at home.

Compared with the initial reaction to peanut, 11 of 35 (31%) reactions resulting from accidental ingestion were more severe, 14 (40%) were of similar severity, and 10 (29%) were less severe. Seven of the accidental exposures were attributed to skin contact with peanut, 26 to peanut ingestion, and 1 to mucosal contact with a peanut in a child who had inserted a peanut into a nostril. Twelve reactions were a result of foods overtly containing peanut and 22 to foods in which the peanut content was unknown. For one of the children, the mode of contact and type of food ingested was unknown. Fourteen accidental exposures occurred at home, 1 at a school permitting peanut, 6 at a

restaurant, and 12 in the homes of a friend or relative; in 2 cases, the location was not specified.

Neither univariate nor multivariate logistic regression analyses identified any clinically important associations with inadvertent exposure to peanut. With only a small number of accidental exposures observed, CIs for all estimated odds ratios tended to be very wide, so our results were inconclusive rather than truly negative for the variables we investigated.

### DISCUSSION

We have shown that children with peanut allergy residing in Quebec had an annual incidence rate of accidental exposure to peanut of 14.3%. Our finding is consistent with that reported in a recent study,<sup>18</sup> but our rate is substantially lower than that described in the study by Bock and Atkins<sup>7</sup> published about 15 years before and the study by Vander Leek et al<sup>17</sup> published only 5 years before. Despite our attempt to identify predictors of accidental exposure, we were unable to do so, potentially because of an inadequate sample or because we did not consider appropriate factors (such as parental/caregiver level of awareness of peanut allergy and child's degree of peanut sensitivity).

In contrast with most previous studies,<sup>7,16,17</sup> we recruited a larger sample, included many children with peanut allergy attending schools prohibiting peanut, and examined potential predictors associated with inadvertent exposure. Although our response rate was modest, we were able to compare participants with nonparticipants and found relatively similar characteristics between the 2 groups. Nevertheless, we cannot exclude nonresponse bias, because nonparticipants may have differed in terms of characteristics for which we were unable to obtain information. The parents of participants may have been older, more educated, and more likely to be employed. Most were in their early 40s, almost 60% had completed a university degree, and 77% were employed. These

factors may have contributed to the low rate of accidental exposure in our study, because such parents may have had a better understanding of the management and implications of having peanut allergy.

In contrast, by assuming that the date of diagnosis of peanut allergy was the date of the first reaction rather than the date of confirmatory testing, we are potentially inflating our estimates of the rate of accidental exposure. It is possible that some families did not recognize their children's first allergic reaction as evidence of peanut allergy and allowed their children to continue to consume peanut until the diagnosis was confirmed by a physician. Therefore, we hypothesized that our annual incidence rate of accidental exposure may be lower if our date of diagnosis was defined as the date of confirmatory testing. When the annual incidence rate of accidental exposure was re-estimated by using the date of confirmatory testing as the date of diagnosis, it fell to 12.3% (95% CI, 7.8% to 18.5%).

In our study, only 1 of 35 accidental exposures occurred in school, with the majority occurring at the patient's home or home of a friend or relative. Others have reported that accidental exposures are much more common in schools.<sup>32-35</sup> Interestingly, in our study, only 20% of children attended a school permitting peanut, which likely contributed to the low accidental exposure rate in schools. Many schools in Montreal have widely implemented peanut-free policies to reduce the risk of accidental exposure for students with peanut allergy. These policies prohibit peanut either in classes attended by children with peanut allergy or throughout the entire school; discourage sharing of food between children; and encourage hand washing and washing of utensils, toys, and food surfaces. In Montreal, 107 of 143 primary schools surveyed had peanut-free policies (Turnbull E, Unpublished data, December 2005). Although our very low rate of accidental exposures in schools may suggest that instituting peanut avoidance guidelines may be beneficial, there are currently no definitive data examining their effectiveness. Our group is currently examining the effectiveness of such policies in reducing the peanut content of school children's lunches.<sup>36-38</sup> Although there appears to be increasing awareness of food allergies in the public sector, it is of concern that accidental exposures continue to occur at home, underscoring the critical importance of education of the family, friends, and other caregivers involved with a child with peanut allergy.

We speculate that some of the accidental exposures in our study may have resulted from both mislabeling by food manufacturers and misreading of labels by parents and caregivers. Despite changes made in the food industry, mislabeling still occurs.<sup>39-43</sup> For example, Vadas and Perelman<sup>41</sup> studied the peanut protein levels in chocolate bars from North America and Europe that did not list peanut as an ingredient and found undeclared levels of peanut protein in bars imported from Europe. Schappi et al<sup>42</sup> examined hidden peanut allergens in foods declared to be peanut-free and found 19 of 46 products had undeclared levels of peanut protein. Vierk et al<sup>40</sup> from the United States Center for Food Safety and Applied Nutrition

reported that in 1999, of 659 recalled foods, 236 had at least 1 undeclared allergen, with peanut detected in 15% of recalled products. Reasons for recall included omission of the ingredient on the label, ingredient errors, manufacturing equipment cross-contamination, and errors by ingredient suppliers or manufacturing firm employees. It is possible that North America has attained a standard level of safety and reliability for individuals with peanut allergy; however, this may not be the case in other countries. In Europe, an ingredient is required to appear on the label only if it constitutes more than 25% of the product.<sup>42</sup> Even though parents of children with peanut allergy are taught the importance of reading food labels, this practice is still difficult for many. Joshi et al<sup>44</sup> reported that 54% of parents of children with peanut allergy failed to read commercial food labels appropriately.

Although the accidental exposure rate observed in our study was low, 57% of accidental exposures were at least of moderate severity. Of these, only 20% were appropriately treated with epinephrine, and 14 of 20 (70%) were not managed by a physician. Similar to previous studies, which have demonstrated that subsequent allergic reactions to peanut may increase in severity compared with the initial reaction,<sup>17,23</sup> in our study, 31% of accidental exposures were more severe than the initial reaction. In a study of 101 families prescribed self-injectable epinephrine, only 71% had epinephrine on hand, 10% had devices beyond the labeled expiration date, and 32% could correctly demonstrate proper use of the device.<sup>45</sup> These data are alarming and indicate the need to educate both parents and physicians more effectively on the management of allergic reactions, given that 125 to 150 preventable fatal anaphylactic reactions to food occur annually in the United States.<sup>46</sup> Ewan and Clark<sup>18</sup> have recently reported that food allergy management plans for patients, parents, and school staff can substantially decrease the rate of accidental exposure.

Although we have reported that accidental exposures to peanut occur at a lower frequency than reported 15 years before, a further reduction is desirable. It likely could be achieved through enhanced patient and parental education on peanut avoidance and enforcement of more stringent food manufacturing standards and more accurate food labeling that will provide clearer consumer directives.

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