Original Article

Impact of Reaction Setting on the Management, Severity, and Outcome of Pediatric Food-Induced Anaphylaxis: A Cross-Sectional Study

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What is already known on this topic? Food-induced anaphylaxis (FIA) is common among children and is frequently incorrectly managed. Data on the impact of reaction location on the management, severity, and outcome of FIA in children are limited.

What does this article add to our knowledge? Home was the most common location for FIA, followed by school/daycare, other locations, and restaurants. Prehospital epinephrine autoinjector use was highest at school/daycare. Reaction severity and outcomes were not associated with the setting of FIA.

How does this study impact current management guidelines? Our findings suggest that policies and training on FIA at school/daycare contribute to the correct prehospital management of pediatric FIA and that setting-specific interventions are needed to increase prompt FIA recognition and management.

BACKGROUND: Prompt epinephrine autoinjector (EAI) use is the primary treatment for anaphylaxis. However, limited Canadian data exist on the impact of reaction location on EAI use for food-induced anaphylaxis (FIA).

OBJECTIVE: We sought to investigate the setting, management, and severity of pediatric FIA.

METHODS: We recruited children presenting with FIA from 11 Canadian emergency departments. Patient demographics and

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Abbreviations used
aOR- Adjusted odds ratio
C-CARE- Cross-Canada Anaphylaxis Registry
ED- Emergency department
EAI- Epinephrine autoinjector
FIA- Food-induced anaphylaxis
NIAID/FAAN- National Institute of Allergy and Infectious Diseases/Food Allergy and Anaphylaxis Network

the setting, management, and symptoms of FIA were collected by standardized questionnaire. Factors associated with prehospital EAI use and reaction severity were determined by logistic regression.

RESULTS: We recruited 3,604 children; 60.2% were male and the median age was 5.0 years (interquartile range 1.8−11.0). Among cases with a known location of FIA (85.0%), home was the most common setting (68.1%), followed by school/daycare (12.8%), other locations (11.4%; eg, park, car), and restaurants (7.4%). In the prehospital setting, EAI was administered in 36.7% of reactions at home, 66.7% in school/daycare, 40.2% in other locations, and 44.5% in restaurants. Relative to reactions occurring at school/daycare, prehospital EAI use was less likely at home (adjusted odds ratio [aOR] 0.80; 95% CI 0.76−0.84), in restaurants (aOR 0.81; 95% CI 0.75−0.87), and in other settings (aOR 0.77; 95% CI 0.73−0.83), when data were adjusted for reaction severity, sex, age, comorbidities, and province. The FIA setting was not associated with reaction severity or hospitalization.

CONCLUSIONS: Prehospital EAI use was higher at school/daycare than in other settings, potentially owing to the presence of policies and training on FIA. Setting-specific interventions including educational programs and policies/laws mandating training and stocking an EAI may improve anaphylaxis recognition and treatment. **(J Allergy Clin Immunol Pract 2022;■:■-■)**

Key words: *Anaphylaxis; Pediatric; Food allergy; Epinephrine; Location*

INTRODUCTION

Food allergies are becoming increasingly prevalent[1] and precipitate significant morbidity and mortality.[2,3] Among the 8% of American children with food allergies, 38.7% have experienced food-induced anaphylaxis (FIA)[4] and 42.0% have visited an emergency department (ED) for an allergy-related reason.[5] The first-line management of anaphylaxis is prompt and correctly executed treatment with epinephrine,[6] whereas delayed treatment is associated with an increased risk of biphasic reactions[6] and a fatal outcome.[3] However, in the prehospital setting, a meta-analysis by our team found that epinephrine autoinjector (EAI) was used in only 21% of cases of pediatric FIA.[7]

A recent American study identified one's home as the most common setting for an allergic reaction to food, followed by restaurants and schools.[8] Several studies have identified suboptimal knowledge and training of restaurant and school staff on FIA recognition and management.[9-12] In restaurants, many individuals with food allergies do not inform restaurant staff of their allergy when ordering[13] and many do not regularly carry an EAI.[14,15] Moreover, whereas provinces such as Ontario[16] and Alberta[17] have either stipulated laws or endorsed policies related to the management of anaphylaxis at schools, it is not mandatory for Canadian restaurant personnel to be trained on the management of anaphylaxis, nor to stock EAIs.[18] Although this disparity may impact the use of EAIs, no Canadian data evaluate the effect of setting (eg, school, restaurant, home) on FIA management (eg, prehospital EAI use) and outcomes (eg, reaction severity, hospitalization). Addressing this knowledge gap would inform guidelines, policies, and training targeted to specific settings to facilitate FIA recognition and appropriate management with EAI. Therefore, we aimed to evaluate the impact of reaction setting on the management and outcome of FIA.

METHODS

Study design

This cross-sectional study was conducted as part of the Cross-Canada Anaphylaxis Registry (C-CARE),[19-25] which recruits patients presenting with anaphylaxis at various Canadian EDs. Data were collected from February 2011 to February 2022.

Study recruitment and questionnaire

Pediatric patients (<18 years of age) presenting to the ED and fulfilling the criteria for anaphylaxis[26,27] and their caregivers were queried on their interest in participating in the C-CARE registry by their treating ED physician. Interested caregivers and their children were then approached by a trained member of the study team who obtained informed written consent and administered a standardized questionnaire. The questionnaire queried on participants' demographics and comorbidities, the trigger of anaphylaxis, presenting symptoms, location of reaction, prehospital and in-hospital management, and outcome (eg, hospitalization). Cases of anaphylaxis that were initially missed were retrospectively recruited to the study by medical record review using a standardized data extraction form and a previously validated algorithm.[28] In cases of missing or discordant data, clarification was sought by contacting the participant (when recruited prospectively) and/or by reviewing their medical records.

Study locations

Participants were enrolled from 11 EDs spanning 5 Canadian provinces. In Québec, patients were recruited from the Montréal Children's Hospital, Royal Victoria Hospital, Montréal General Hospital, Hôpital Sainte-Justine, and Hôpital du Sacré-Coeur de Montreal. In Newfoundland and Labrador, we recruited participants from the Janeway's Children's Health and Rehabilitation Centre. In addition, patients were recruited from the following sites in Ontario: London Health Sciences Center, the Hospital for Sick Children, and St. Joseph's Healthcare Hamilton. Finally, patients were also recruited from the British Columbia Children's Hospital in British Columbia and from the Foothills Medical Centre located in Alberta. All study locations received ethics approval for the C-CARE study from their respective institutional review board.

Classifications/definitions

Anaphylaxis was defined according to the National Institute of Allergy and Infectious Diseases/Food Allergy and Anaphylaxis Network (NIAID/FAAN) definition for anaphylaxis as a reaction involving at least 2 systems and/or hypotension.[26] Upon questionnaire completion, study recruiters verified that the participant

TABLE I. Patient demographics, province of recruitment, and comorbidities

Variable	Restaurant (n = 227)	Work (n = 10)	Home (n = 2,087)	School/daycare (n = 393)	Unknown (n = 48)	Missing location (n = 491)	Other (n = 348)	Total (n = 3,604)
Demographics, **n** (%)								
Male **s**ex	119 (52.4)	3 (30.0)	1,258 (60.3)	241 (61.3)	36 (75.0)	291 (59.3)	223 (64.1)	2,171 (60.2)
Age at **r**eaction (IQR)	10.0 (4.3−14.9)	17.0 (11.9−17.6)	3.9 (1.2−9.0)	6.4 (2.9−13.3)	5.9 (2.5−9.6)	6.5 (2.8−12.0)	7.0 (3.5−12.0)	5.0 (1.8−11.0)
Retrospective **r**ecruitment	110 (48.5)	3 (30.0)	1,263 (60.5)	165 (42.0)	0 (0.0)	491 (100.0)	178 (51.1)	2,210 (61.3)
Province of **r**ecruitment, **n** (%)								
Newfoundland and Labrador	0 (0.0)	0 (0.0)	4 (0.2)	2 (0.5)	0 (0.0)	0 (0.0)	1 (0.3)	7 (0.2)
Québec	155 (68.3)	5 (50.0)	1,649 (79.0)	333 (84.7)	25 (52.1)	331 (67.4)	235 (67.5)	2,733 (75.8)
Ontario	29 (12.8)	2 (20.0)	234 (11.2)	31 (7.9)	10 (20.8)	14 (2.9)	45 (12.9)	365 (10.1)
Alberta	2 (0.9)	0 (0.0)	1 (0.0)	0 (0.0)	0 (0.0)	5 (1.0)	1 (0.3)	9 (0.2)
British Columbia	41 (18.1)	3 (30.0)	199 (9.5)	27 (6.9)	13 (27.1)	141 (28.7)	66 (19)	490 (13.6)
Comorbidities, **n** (%)								
Previously known food allergy	163 (71.8)	7 (70.0)	1,180 (56.5)	292 (74.3)	25 (52.1)	319 (65.0)	258 (74.1)	2,244 (62.3)
Drug allergy	3 (1.3)	0 (0.0)	35 (1.7)	8 (2)	0 (0.0)	16 (3.3)	4 (1.1)	66 (1.8)
Venom allergy	0 (0.0)	0 (0.0)	2 (0.1)	1 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	3 (0.1)
Other allergy (eg, pet dander, dust mites)	10 (4.4)	1 (10.0)	68 (3.3)	15 (3.8)	3 (6.3)	25 (5.1)	14 (4.0)	136 (3.8)
Asthma	30 (13.2)	2 (20.0)	274 (13.1)	74 (18.8)	8 (16.7)	82 (16.7)	69 (19.8)	539 (15.0)
Heart disease	0 (0.0)	0 (0.0)	1 (0.0)	1 (0.3)	1 (2.1)	0 (0.0)	0 (0.0)	3 (0.1)
Atopic dermatitis	34 (15.0)	1 (10.0)	360 (17.2)	63 (16.0)	8 (16.7)	77 (15.7)	54 (15.5)	597 (16.6)
Other comorbidity	16 (7.0)	1 (10.0)	145 (6.9)	26 (6.6)	7 (14.6)	39 (7.9)	27 (7.8)	261 (7.2)
No comorbidity	32 (14.1)	1 (10.0)	534 (25.6)	60 (15.3)	12 (25.0)	86 (17.5)	43 (12.4)	768 (21.3)

IQR, Interquartile range.

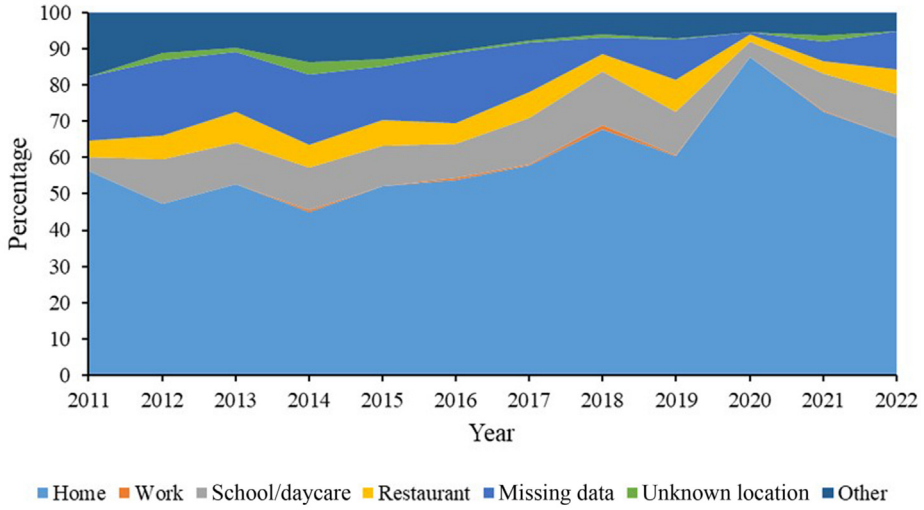

FIGURE 1. Stacked graph of the percentages of anaphylaxis cases stratified by the location of reaction occurrences per year.

satisfied at least 1 of the NIAID/FAAN categories for anaphylaxis.[26,27] Participants were excluded from the study if they fulfilled any of the following: symptom onset more than 8 hours after exposure to the trigger, symptom resolution prior to ED presentation, or symptom duration less than 1 hour. In cases of uncertainty over the diagnosis of anaphylaxis, M.B.S., an experienced pediatric allergist and immunologist, adjudicated.

Anaphylaxis severity was classified according to a modified Muraro et al.[29] grading scale. Anaphylaxis was classified as mild if it included only the following: pruritus, urticaria, flushing, rhinoconjunctivitis, angioedema, a single episode of emesis, or mild abdominal pain.[29] Reactions classified as moderate in severity involved throat tightness, stridor, crampy abdominal pain, multiple episodes of emesis, diarrhea, difficulty breathing, or wheezing.[29] Anaphylaxis was categorized as severe if it comprised any of the following: cyanosis, hypotension, hypoxia, fecal or urinary incontinence in a toilet-trained child, or shock.[29] Anaphylaxis grading was performed independently by 2 reviewers (C.P. and S.G.), and in cases of disagreement, a third reviewer adjudicated (M.B.S.).

A restaurant setting was defined as an establishment preparing and/or serving food that is not school, home, or the workplace (eg, food trucks, ice cream stands, food courts).

Statistical analyses

All data analyses were performed using RStudio (2021, version 4.0.4, R Core Team, Vienna, Austria). Categorical variables were presented as percentages and continuous variables were presented as a median with an interquartile range. Univariate and multivariate logistic regression were performed to investigate factors associated with FIA management, reaction setting, and reaction severity/hospitalization. All variables were dichotomized apart from age. To compare the characteristics of retrospectively and prospectively recruited participants, we used the χ^2 test for proportions and an independent 2-sample *t*-test for continuous variables.

RESULTS

Demographics, reaction settings, and comorbidities

A total of 3,604 cases of FIA in children were recruited (Table I). Most (61.3%) cases were retrospectively recruited; data stratified by recruitment method are presented in Table E1 (available in this article's Online Repository at www.jaci-inpractice.org). Patients were predominantly male (60.2%), and the median age was 5.0 years (interquartile range 1.8−11.0). A total of 13.6% of questionnaires/medical charts had missing data on the reaction setting, and in 1.3% of cases, the patient was unsure where the reaction took place. Among cases with known locations (85.0%), most episodes of FIA occurred at home (68.1%), or at school/daycare (12.8%). Less-frequent settings for FIA were other locations (11.4%; eg, park, car, party; Table E2; available in this article's Online Repository at www.jaci-inpractice.org), restaurants (7.4%) and in the workplace (0.3%). Most episodes were recruited in EDs in Quebec (75.8%), British Columbia (13.6%), or Ontario (10.1%). Prior to the episode of FIA, 62.3% of patients had been diagnosed with any food allergy. Among these cases, 63.4% had been diagnosed with an allergy to the suspected trigger. The most common comorbidities were atopic dermatitis (16.6%) and asthma (15.0%).

Temporal changes

The relative proportion of cases of FIA recruited per year according to location demonstrated a reasonably constant distribution of cases per setting of FIA (Figure 1). However, during the emergence of the coronavirus disease 2019 (COVID-19) pandemic (March to December, 2020), there was an increased likelihood of reactions occurring at home (adjusted odds ratio [aOR] 1.05; 95% CI 1.03−1.07), when adjusting for sex and age (Table E3; available in this article's Online Repository at www.jaci-inpractice.org).

Reaction triggers, severity, and outcomes

The majority of cases of FIA (92.1%) were triggered by ingestion, which was consistent across all settings (Table II). In restaurants, the most common trigger of FIA (34.4%) was unknown triggers, whereas peanuts were the most common culprit at home (19.5%) and at school/daycare (18.6%). Across all settings, reactions were most frequently moderate in severity (73.6%) and rarely resulted in hospitalization (2.2%).

TABLE II. Reaction characteristics

Variable	Restaurant (n = 227)	Work (n = 10)	Home (n = 2,087)	School/daycare (n = 393)	Unknown (n = 48)	Missing location (n = 491)	Other (n = 348)	Total (n = 3,604)
Exposure route, n (%)								
Ingestion	211 (93.0)	10 (100.0)	1,950 (93.4)	349 (88.8)	44 (91.7)	450 (91.6)	305 (87.6)	3,319 (92.1)
Contact	2 (0.9)	0 (0.0)	33 (1.6)	13 (3.3)	1 (2.1)	12 (2.4)	14 (4.0)	75 (2.1)
Inhaled	1 (0.4)	0 (0.0)	4 (0.2)	5 (1.3)	0 (0.0)	3 (0.6)	6 (1.7)	19 (0.5)
Parenteral	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Unknown	13 (5.7)	0 (0.0)	100 (4.8)	26 (6.6)	3 (6.3)	26 (5.3)	23 (6.6)	191 (5.3)
Reaction trigger, n (%)								
Peanut	40 (17.6)	1 (10.0)	408 (19.5)	73 (18.6)	15 (31.3)	104 (21.2)	95 (27.3)	736 (20.4)
Tree nut	24 (10.6)	2 (20.0)	328 (15.7)	27 (6.9)	8 (16.7)	79 (16.1)	37 (10.6)	505 (14.0)
Walnut	1 (0.4)	0 (0.0)	50 (2.4)	1 (0.3)	2 (4.2)	8 (1.6)	5 (1.4)	67 (1.9)
Hazelnut	4 (1.8)	1 (10.0)	46 (2.2)	6 (1.5)	3 (6.3)	10 (2.0)	8 (2.3)	78 (2.2)
Almond	1 (0.4)	0 (0.0)	19 (0.9)	1 (0.3)	2 (4.2)	5 (1.0)	3 (0.9)	31 (0.9)
Pistachio	5 (2.2)	0 (0.0)	38 (1.8)	2 (0.5)	1 (2.1)	8 (1.6)	3 (0.9)	57 (1.6)
Cashew	6 (2.6)	1 (10.0)	117 (5.6)	6 (1.5)	0 (0.0)	26 (5.3)	11 (3.2)	167 (4.6)
Pecan	1 (0.4)	0 (0.0)	13 (0.6)	2 (0.5)	0 (0.0)	5 (1.0)	2 (0.6)	23 (0.6)
Macadamia	0 (0.0)	0 (0.0)	4 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (0.1)
Brazil nut	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.4)	1 (0.3)	3 (0.1)
Unspecified	6 (2.6)	0 (0.0)	41 (2.0)	9 (2.3)	0 (0.0)	15 (3.1)	4 (1.1)	75 (2.1)
Unknown nut	10 (4.4)	0 (0.0)	123 (5.9)	22 (5.6)	3 (6.3)	34 (6.9)	18 (5.2)	210 (5.8)
Milk	8 (3.5)	1 (10.0)	149 (7.1)	46 (11.7)	1 (2.1)	21 (4.3)	28 (8.0)	254 (7.0)
Egg	12 (5.3)	1 (10.0)	206 (9.9)	32 (8.1)	1 (2.1)	21 (4.3)	17 (4.9)	290 (8.0)
Fish	2 (0.9)	0 (0.0)	43 (2.1)	17 (4.3)	1 (2.1)	9 (1.8)	6 (1.7)	78 (2.2)
Shellfish	10 (4.4)	0 (0.0)	43 (2.1)	2 (0.5)	2 (4.2)	20 (4.1)	2 (0.6)	79 (2.2)
Soy	0 (0.0)	0 (0.0)	11 (0.5)	5 (1.3)	0 (0.0)	3 (0.6)	5 (1.4)	24 (0.7)
Wheat	3 (1.3)	0 (0.0)	21 (1.0)	10 (2.5)	0 (0.0)	0 (0.0)	2 (0.6)	36 (1.0)
Sesame	10 (4.4)	0 (0.0)	66 (3.2)	12 (3.1)	1 (2.1)	11 (2.2)	9 (2.6)	109 (3.0)
Kiwi	1 (0.4)	0 (0.0)	26 (1.2)	4 (1.0)	0 (0.0)	5 (1.0)	1 (0.3)	37 (1.0)
Other	20 (8.8)	1 (10.0)	214 (10.3)	48 (12.2)	2 (4.2)	44 (9.0)	33 (9.5)	362 (10.0)
Unknown	78 (34.4)	4 (40.0)	355 (17.0)	67 (17.0)	13 (27.1)	127 (25.9)	80 (23.0)	724 (20.1)
Multiple	9 (4.0)	0 (0.0)	94 (4.5)	28 (7.1)	1 (2.1)	13 (2.6)	15 (4.3)	160 (4.4)
Reaction severity,* n (%)								
Mild	36 (15.9)	0 (0.0)	465 (22.3)	85 (21.6)	9 (18.8)	102 (20.8)	70 (20.1)	767 (21.3)
Moderate	180 (79.3)	9 (90.0)	1,511 (72.4)	282 (71.8)	38 (79.2)	378 (77.0)	253 (72.7)	2,651 (73.6)
Severe	11 (4.8)	1 (10.0)	108 (5.2)	24 (6.1)	1 (2.1)	9 (1.8)	25 (7.2)	179 (5.0)
Hospitalization, n (%)								
Ward	3 (1.3)	1 (10.0)	12 (0.6)	1 (0.3)	1 (2.1)	0 (0.0)	4 (1.1)	23 (0.6)
Intensive care unit	0 (0.0)	1 (10.0)	38 (1.8)	8 (2)	1 (2.1)	1 (0.2)	7 (2.0)	55 (1.5)

grading scale, data were missing for n = 7.
*As defined by the modified Muraro et al[29].

Reaction management

In the prehospital setting, EAI use was 66.7% in reactions that occurred at school/daycare, 50.0% at work, 44.5% in restaurants, 40.2% in other locations, and 36.7% at home (Table III). Data on prehospital EAI use stratified by previously known food allergy and reaction severity are presented in Table E4 (available in this article's Online Repository at www.jaci-inpractice.org). H1-antihistamine use was similar across all settings ranging approximately from 40% to 50%, apart from work (70.0%).

Within the ED, intramuscular epinephrine use was most frequent in reactions occurring at work, in restaurants, and in other settings (50%−60%), and least common when FIA occurred at school/daycare (33.6%). The use of H1-antihistmines in the hospital was consistent across all settings (45%−50%).

A total of 19.8% of patients experiencing FIA did not receive intramuscular epinephrine in either the pre- or the in-hospital setting. Specifically, intramuscular epinephrine was not used in either setting in 9.9% at school/daycare and 16% to 21% in all other settings (Table III).

Factors associated with prehospital EAI use

Data were adjusted for reaction severity, sex, age, asthma, previously known food allergy, and atopic dermatitis. Prehospital EAI use was less likely among reactions occurring at home (aOR 0.80; 95% CI 0.76−0.84), in restaurants (aOR 0.81; 95% CI

TABLE III. Management of anaphylaxis

Variable	Restaurant (n = 227)	Work (n =0)	Home (n = 2,087)	School/daycare (n = 393)	Unknown (n = 48)	Missing location (n = 491)	Other (n = 348)	Total (n = 3,604)
Did not receive prehospital or in-hospital intramuscular epinephrine	39 (17.2)	2 (20.0)	443 (21.2)	39 (9.9)	7 (14.6)	128 (26.0)	57 (16.4)	715 (19.8)
Severity: mild	9 (4.0)	0 (0.0)	137 (6.6)	15 (3.8)	4 (8.3)	39 (7.9)	18 (5.2)	222 (6.2)
Severity: moderate	28 (12.3)	1 (10.0)	292 (14.0)	24 (6.1)	3 (6.3)	88 (17.9)	36 (10.3)	472 (13.1)
Severity: severe	2 (0.9)	1 (10.0)	12 (0.6)	0 (0.0)	0 (0.0)	0 (0.0)	3 (0.9)	18 (0.5)
Prehospital, n (%)								
Intramuscular epinephrine	101 (44.5)	5 (50.0)	766 (36.7)	262 (66.7)	14 (29.2)	172 (35.0)	140 (40.2)	1,460 (40.5)
Severity: mild	9 (4.0)	0 (0.0)	124 (5.9)	41 (10.4)	2 (4.2)	28 (5.7)	20 (5.7)	224 (6.2)
Severity: moderate	88 (38.8)	5 (50.0)	582 (27.9)	198 (50.3)	11 (22.9)	142 (28.9)	111 (31.9)	1,137 (31.5)
Severity: severe	4 (1.8)	0 (0.0)	59 (2.8)	21 (5.3)	1 (2.1)	2 (0.4)	9 (2.6)	96 (2.7)
Mean number of doses (SD)	1.2 (0.4)	1.2 (0.4)	1.2 (0.5)	1.2 (0.6)	1.3 (0.5)	1.1 (0.4)	1.3 (0.6)	1.2 (0.5)
H1-antihistamines	102 (44.9)	7 (70.0)	950 (45.5)	155 (39.4)	22 (45.8)	229 (46.6)	172 (49.4)	1,637 (45.4)
H2-antihistamines	2 (0.9)	0 (0.0)	13 (0.6)	4 (1.0)	0 (0.0)	3 (0.6)	5 (1.4)	27 (0.7)
Beta agonist	17 (7.5)	1 (10.0)	113 (5.4)	25 (6.4)	3 (6.3)	39 (7.9)	35 (10.1)	233 (6.5)
Corticosteroids	0 (0.0)	0 (0.0)	25 (1.2)	3 (0.8)	0 (0.0)	7 (1.4)	11 (3.2)	46 (1.3)
Intravenous fluids	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.3)	1 (0.0)
Other treatment	8 (3.5)	0 (0.0)	86 (4.1)	17 (4.3)	2 (4.2)	19 (3.9)	31 (8.9)	163 (4.5)
No treatment	55 (24.2)	2 (20.0)	654 (31.3)	54 (13.7)	14 (29.2)	123 (25.1)	86 (24.7)	988 (27.4)
Unknown	3 (1.3)	0 (0.0)	11 (0.5)	0 (0.0)	1 (2.1)	25 (5.1)	9 (2.6)	49 (1.4)
In-hospital N (%)								
Intramuscular epinephrine	120 (52.9)	6 (60.0)	1017 (48.7)	132 (33.6)	31 (64.6)	222 (45.2)	176 (50.6)	1,704 (47.3)
Severity: mild	19 (8.4)	0 (0.0)	224 (10.7)	30 (7.6)	4 (8.3)	37 (7.5)	33 (9.5)	347 (9.6)
Severity: moderate	94 (41.4)	6 (60.0)	736 (35.3)	92 (23.4)	26 (54.2)	175 (35.6)	125 (35.9)	1,254 (34.8)
Severity: severe	7 (3.1)	0 (0.0)	57 (2.7)	10 (2.5)	1 (2.1)	9 (1.8)	18 (5.2)	102 (2.8)
Mean number of doses (SD)	1.1 (0.3)	1.0 (0.0)	1.1 (0.4)	1.1 (0.3)	1.2 (0.6)	1.1 (0.3)	1.3 (0.7)	1.1 (0.4)
Intravenous epinephrine drip	3 (1.3)	0 (0.0)	15 (0.7)	3 (0.8)	0 (0.0)	4 (0.8)	5 (1.4)	30 (0.8)
H1-antihistamines	104 (45.8)	5 (50.0)	931 (44.6)	164 (41.7)	23 (47.9)	224 (45.6)	170 (48.9)	1,621 (45.0)
H2-antihistamines	28 (12.3)	4 (40.0)	166 (8.0)	34 (8.7)	7 (14.6)	49 (10.0)	38 (10.9)	326 (9.0)
Beta agonist	28 (12.3)	1 (10.0)	163 (7.8)	30 (7.6)	7 (14.6)	52 (10.6)	37 (10.6)	318 (8.8)
Corticosteroids	81 (35.7)	5 (50.0)	561 (26.9)	112 (28.5)	20 (41.7)	141 (28.7)	117 (33.6)	1,037 (28.8)
Intravenous fluids	14 (6.2)	3 (30.0)	87 (4.2)	16 (4.1)	2 (4.2)	8 (1.6)	32 (9.2)	162 (4.5)
Other treatment	27 (11.9)	1 (10.0)	188 (9.0)	20 (5.1)	5 (10.4)	45 (9.2)	40 (11.5)	326 (9.0)
No treatment	19 (8.4)	1 (10.0)	319 (15.3)	67 (17.0)	1 (2.1)	47 (9.6)	29 (8.3)	483 (13.4)
Unknown	1 (0.4)	0 (0.0)	10 (0.5)	0 (0.0)	0 (0.0)	3 (0.6)	3 (0.9)	17 (0.5)

0.75−0.87), and in other settings (aOR 0.77; 95% CI 0.73−0.83) relative to school/daycare (Table IV). Prehospital EAI use was also less likely when reactions occurred in British Columbia (aOR 0.84; 95%CI 0.79−0.90), but more likely in patients previously known for food allergies (aOR 1.40; 95% CI 1.36−1.45). Sensitivity analyses of prehospital EAI use stratified by reaction setting were consistent with overall estimates (Table E5; available in this article's Online Repository at www.jaci-inpractice.org).

A separate regression model was used to investigate the effect of province of recruitment with prehospital EAI use in each individual setting (Table E6; available in this article's Online Repository at www.jaci-inpractice.org). Pre-hospital EAI use was least common in British Columbia among reactions occurring at home (aOR 0.88; 95% CI 0.81−0.95) or at school/daycare (aOR 0.85; 95% CI 0.79−0.90), but not in restaurants (aOR 0.80; 95% CI 0.64−1.00), when adjusting for previously known food allergy, sex, and age. A summary of the provincial policies governing anaphylaxis management in schools are presented in Table E7 (available in this article's Online Repository at www.jaci-inpractice.org).

Factors associated with reaction severity and outcome

When adjusting for sex, age, previously known food allergy, asthma, and atopic dermatitis, no FIA settings were significantly associated with mild or moderate to severe reactions or hospitalization (Table E8; available in this article's Online Repository at www.jaci-inpractice.org). Asthma (aOR 1.07; 95% CI 1.02−1.11) and age (aOR 1.02; 95% CI 1.01−1.02) were associated with moderate to severe anaphylaxis, but not hospitalization.

Factors associated with reaction setting

We analyzed the association of reaction trigger and previously known food allergy with reaction setting, while adjusting for sex

TABLE IV. Factors associated with prehospital EAI use

	Prehospital EAI use	
Variable	Univariate (95% CI)	Multivariate (95% CI)
Setting: home	0.86 (0.83−0.89)*	0.80 (0.76−0.84)*
Setting: restaurant	1.03 (0.97−1.10)	0.81 (0.75−0.87)*
Setting: school/daycare	1.33 (1.27−1.40)*	Reference
Setting: work	1.09 (0.80−1.48)	0.84 (0.63−1.11)
Setting: other	0.99 (0.93−1.04)	0.77 (0.73−0.83)*
Male sex	1.02 (0.99−1.06)	1.02 (0.99−1.06)
Age at reaction	1.02 (1.01−1.02)*	1.00 (1.00−1.00)*
Severity: mild	0.87 (0.83−0.90)*	0.91 (0.88−0.95)*
Severity: moderate	1.09 (1.06−1.13)*	Reference
Severity: severe	1.15 (1.07−1.24)*	1.11 (1.04−1.19)*
Known food allergy	1.44 (1.40−1.49)*	1.40 (1.36−1.45)*
Asthma	1.10 (1.05−1.15)*	1.01 (0.97−1.06)
Atopic dermatitis	0.94 (0.90−0.98)*	0.98 (0.94−1.02)
Province: Quebec	1.08 (1.04−1.12)*	0.98 (0.93−1.03)
Province: Ontario	1.03 (0.98−1.09)	Reference
Province: Newfoundland and Labrador	0.89 (0.62−1.28)	0.86 (0.62−1.21)
Province: Alberta	1.16 (0.84−1.60)	1.55 (1.00−2.41)
Province: British Columbia	0.86 (0.82−0.90)*	0.84 (0.79−0.90)*

*Denotes statistical significance.

and age (Table E9; available in this article's Online Repository at www.jaci-inpractice.org). Tree nuts were a more likely trigger at home (aOR 1.11;, 95% CI 1.05−1.17). Reactions occurring at school/daycare were positively associated with fish (aOR 1.11; 95% CI 1.02−1.21) and negatively associated with peanuts (aOR 0.96; 95% CI 0.92−0.99), tree nuts (aOR 0.91; 95% CI 0.87−0.95), and shellfish (aOR 0.89; 95% CI 0.81−0.97). FIA in restaurants was more likely triggered by shellfish (aOR 1.12; 95% CI 1.04−1.20) and unknown triggers (aOR 1.06; 95% CI 1.03−1.10). FIA in patients with a previously known food allergy was more likely at school/daycare (aOR 1.06; 95% CI 1.03−1.08) and less likely at home (aOR 0.90; 95% CI 0.87−0.93). Reactions at school/daycare were more likely in Québec (aOR 1.04; 95% CI 1.00−1.08) and reactions in restaurants were more likely in Alberta (aOR 1.41; 95% CI 1.10−1.82). No significant associations were noted in the province of recruitment and FIA at home.

DISCUSSION

In this cross-sectional study of the setting, management, and severity of pediatric FIA, data from a pan-Canadian registry provide evidence that home is the most common location for FIA, followed by school/daycare, other locations, and restaurants. Patients with previously known food allergies were more likely to have reactions at school/daycare and less likely to have reactions at home. Compared with school/daycare, prehospital EAI use was less likely among reactions occurring at home, other settings, and restaurants notwithstanding previously known food allergy or reaction severity. No differences were detected in reaction severity or outcomes between reaction settings.

Home was the most common setting for FIA in our results, which is in line with previous studies.[8,30,31] Although EAIs are typically more accessible at home than in other locations, FIA occurring at home had the lowest rate of prehospital EAI treatment. Parental fear of misusing the EAI or harming the child[32] and uncertainty of the signs and symptoms of anaphylaxis[33] may contribute to prehospital EAI underuse in the home setting. Moreover, parents may be more likely than teachers/caregivers to adopt a watchful waiting approach to FIA rather than calling emergency medical services and/or administering an EAI.[34,35] Therefore, programs aimed at educating parents on FIA recognition and promoting administration of an EAI to all cases of anaphylaxis may increase EAI use in the home setting. Because anaphylaxis occurring at home was more common among patients without a known food allergy, increased training for first responders on the recognition and management of FIA with intramuscular epinephrine is also needed.[36]

We found that prehospital EAI use was highest among reactions occurring at school/daycare, which is consistent with a recent American study.[37] This may be due to the presence of policies and guidelines advocating for mandatory EAI stocking and training on anaphylaxis management at school/daycare.[35,38] Although Ontario[16] and, more recently, Alberta[17] have introduced legislation to increase anaphylaxis training and awareness in schools, other provinces have not followed suit. Moreover, there remains significant heterogeneity in the implementation of FIA training in schools.[35] Many school personnel have suboptimal knowledge on which students have food allergies, the symptoms of anaphylaxis, where EAIs are located, and how to administer an EAI.[12,35,39,40] Consequently, there is a continued need for standardizing and mandating FIA awareness and management training in the school setting.[35] Interestingly, fish was a more common trigger at school/daycare, which may be due to a lack of awareness of fish allergies.[41]

Our results found a lower proportion of cases occurring in restaurants compared with those in a recent American report (21% vs 7.4%).[8] Moreover, prehospital EAI use in restaurants was much lower than our findings (28% vs 44.5%).[8] However, this study enrolled persons of any age, unlike our study, which was restricted to children, which may account for the observed disparity between the studies. In addition, our results identified that prehospital EAI use was low in the restaurant setting. Indeed, certain municipalities and restaurant chains have adopted EAI programs of their own.[18,42] However, there is a lack of government legislation on mandatory EAI stocking and training in restaurants.

Our results elucidate several key inadequacies in the management of FIA across different settings. Future objectives to address these shortfalls may include developing setting-specific questionnaires to assist in formulating a site-specific approach to FIA management. For instance, among FIA occurring in restaurants, it would be valuable to know whether the server was notified of the allergy prior to ordering. Inquiring about the identity of the person who administered the EAI (eg, self-administration, school nurse, teacher) and the source of the EAI (eg, personal, school stock, friend) may provide valuable insight on whom to target with further prevention and management strategies. Investigating why epinephrine was not administered in certain cases would be beneficial to provide insight on barriers to EAI use. This would address factors such as inadequate training, lack of EAI availability, and fear surrounding EAI administration. Finally, investigating the efficacy of the Ontario[16] and Alberta[17] FIA laws at school/daycare will help inform future FIA-related laws in Canada.

Our study is subject to certain limitations. Most participants were recruited from Quebec EDs (75.8%), and very few were recruited from Newfoundland and Labrador and Alberta, which restricted comparisons between provinces. Retrospective recruitment of cases was limited by the information contained in the patient's medical record and, occasionally, did not include the location of the reaction, which may lead to misclassification bias (Table E1). However, the location of FIA was known in 85% of cases. Our study is limited to episodes of FIA presenting to the ED and, therefore, excludes mild cases of FIA that were managed outside the ED. Therefore, our data may be subject to selection bias, but this limitation is shared by all studies recruiting cases of FIA from EDs. The Muraro et al[29] anaphylaxis grading scale was modified to be consistent with the NIAID/FAAN definition of anaphylaxis and to reduce ambiguity/inter-observer variability, which may have led to some misclassifications of anaphylaxis severity. However, this was mitigated by having independent reviewers grade the severity of FIA. Patients were recruited from large urban centers and data may not be generalizable to rural settings. Data were not collected on socioeconomic status or race/ethnicity, which may confound EAI use.[43,44] Nevertheless, we believe that our data provide the most comprehensive and current analysis of the effect of reaction setting on FIA management and severity.

Among Canadian children, home is the most common setting for FIA, followed by school/daycare, other locations, and restaurants. Prehospital EAI use was highest among reactions occurring at school/daycare, which may indicate the efficacy of current FIA laws/policies in schools/daycares. Setting-tailored laws/policies mandating training on FIA recognition and management and potentially EAI stocking may improve FIA management across all settings. Training to increase EAI use at home to approach the level of EAI use in schools is also needed.

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