Deaths, Hospitalizations, and Emergency Department Visits From Food-Related Anaphylaxis, New York City, 2000-2014: Implications for Fatality Prevention

Eugenie Poirot, MPH, PhD; Fangtao He, MS; L. Hannah Gould, PhD, MBA, MS; James L. Hadler, MD, MPH

ABSTRACT

Context: Food-induced anaphylaxis is potentially fatal but preventable by allergen avoidance and manageable through immediate treatment. Considerable effort has been invested in preventing fatalities from nut exposure among school-aged children, but few population-based studies exist to guide additional prevention efforts.

Objectives: To describe the epidemiology and trends of food-related anaphylaxis requiring emergency treatment during a 15-year span in New York City when public health initiatives to prevent deaths were implemented and to understand the situational circumstances of food-related deaths.

Design/Setting/Participants: Retrospective death record review and analysis of inpatient hospital discharges and emergency department (ED) visits in New York City residents, 2000-2014.

Main Outcome: Vital statistics data, medical examiner reports, ED, and hospital discharge data were used to examine risk for death and incidence trends in medically attended food-related anaphylaxis. Potentially preventable deaths were those among persons with a known allergy to the implicated food or occurring in public settings.

Results: There were 24 deaths, (1.6 deaths/year; range: 0-5), 3049 hospitalizations, and 4014 ED visits, including 7 deaths from crustacean, 4 from peanut, and 2 each from tree nut or seeds and fish exposures. Risk for death among those hospitalized or treated in the ED was highest for persons older than 65 years and for those treated for crustacean reactions (relative risk 6.5 compared with those treated for peanuts, 95% confidence interval = 1.9-22.1). Eleven of 16 deaths with medical examiner data were potentially preventable. Hospitalizations (2000-2014) and ED visit rates (2005-2014) were highest for children and those with peanut exposure and increased across periods.

Conclusions: Deaths from food-related anaphylaxis were rare; however, rates of hospitalization and ED visits increased. Prevention efforts related to peanut allergies among children should continue, and additional attention is needed to prevent and treat anaphylaxis among adults, particularly those with known crustacean allergies where case fatality is highest.

KEY WORDS: anaphylaxis, emergency department, food allergy, food-induced fatality, hospitalization

Author Affiliations: *Epidemic Intelligence Service, Division of Scientific Education and Professional Development, Centers for Disease Control and Prevention, Atlanta, Georgia (Dr Poirot); and New York City Department of Health and Mental Hygiene, New York, New York (Drs Poirot, Gould, and Hadler and Mr He).*

The authors thank Wendy Mckelvey and Sarah Walters who contributed to earlier analyses that evolved into this study. They also acknowledge the contributions of Tejinder Singh and Sungwoo Lim for statistical guidance.

Eugenie Poirot was supported by the US Centers for Disease Control and Prevention. Fangtao He, L. Hannah Gould, and James L. Hadler were each supported for this work entirely by funding from the New York City Department of Health and Mental Hygiene. The opinions expressed by the authors contributing to this report do not necessarily reflect the opinions of the Centers for Disease Control and Prevention or the New York City Department of Health and Mental Hygiene.

The authors declare no conflicts of interest.

Food allergies are the most common cause of anaphylaxis outside the hospital setting,[1,2] affecting approximately 9% of the US population.[3] Treatment of suspected anaphylactic reactions with epinephrine immediately upon their onset is crucial to prevent deaths from food allergies. Carrying a prescribed epinephrine autoinjector has long been recommended for persons with potentially life-threatening food allergies, in addition to strict avoidance of foods to which they are allergic.[4,5]

During the past 2 decades, the incidence of food allergies has increased in the United States, raising

Correspondence: *James L. Hadler, MD, MPH, New York City Department of Health and Mental Hygiene, Gotham Center, 42-09 28th St, 8th Floor, WS 8-63, Queens, NY 1101 (jhadler@health.nyc.gov).*

DOI: 10.1097/PHH.0000000000001137

public concern.[1,2,6] Life-threatening food allergies among children in schools and day care settings have been a focus of that concern. This has led to national school-centered recommendations to reduce exposure to common allergens, especially nuts, and design of emergency plans that ensure availability and proper use of epinephrine autoinjectors.[4,7] An additional public health prevention focus has been on helping those of any age with food allergies avoid inadvertent exposure, including requiring regulated food service establishments (eg, restaurants) to clearly label foods that contain common allergens and provide awareness training to food services managers and staff.[8] In New York City (NYC), the Department of Health and Mental Hygiene has supplied epinephrine autoinjectors to schools since 2004 and required posting of food allergy posters in restaurant kitchens since 2009.[9]

Given the unpredictability of who may have a life-threatening food-related anaphylactic reaction and whether they will have immediate access to an epinephrine autoinjector, the National Academy of Sciences has recommended additional research to "define best practices regarding food allergy management (e.g., epinephrine storage) at settings where food is served, … including restaurants, cafeterias, grocery stores, and commercial airliners."[8] This is conceptually similar to the strategic placement of external defibrillators, enabling prompt treatment wherever cardiac arrest may occur. Although at least 1 state has passed legislation permitting restaurants to stock and administer epinephrine autoinjectors,[10] efforts to mandate that restaurants stock epinephrine autoinjectors have failed in other states.[11,12]

During analyses conducted in 2017 and 2018, we examined the epidemiology of severe food-related anaphylaxis requiring emergency treatment during a 15-year span in NYC when public health initiatives to prevent deaths were implemented. Specifically, we described trends in the incidence of food-related emergency department (ED) visits, hospitalizations, and deaths among NYC residents during 2000-2014. A further objective was to understand the circumstances of these food-related anaphylactic deaths to guide prevention efforts.

Methods

Data

Data concerning deaths were obtained from Department of Health and Mental Hygiene's Office of Vital Statistics. We requested a list of deaths with any cause or contributing cause using the *International Classification of Diseases, Ninth Revision* (*ICD-9*) code of 995.0 (anaphylactic shock) or 999.4 (anaphylactic shock because of serum) or *International Classification of Diseases, Tenth Revision* (*ICD-10*) codes of T50.9, T63.2, T63.4, T63.6, T63.9 (T63.x referring to animal or insect stings), T78.0 (food), T78.2 (anaphylactic shock), T80.5 (serum), and T88.6 (correct substance properly administered), consistent with previous studies of deaths.[13-15] All death certificates that listed anaphylaxis were reviewed for possible food exposure. A case of fatal food-related anaphylaxis was defined as a death in an NYC resident during 2000 to 2014, with a death certificate that used *ICD-9* or *ICD-10* codes listed previously and was consistent with food-related anaphylaxis based on literal text data from death certificate cause of death fields. To obtain details about circumstances related to these deaths, we linked death certificates to investigative reports from the NYC Office of the Chief Medical Examiner. Reports were reviewed for additional details, including known allergy to the suspect food, location food was consumed, acute symptoms, medications given before ambulance arrival, and medical status at ambulance and ED arrival.

We obtained inpatient hospital discharges during 2000 to 2014 and ED visit data not resulting in hospitalization during 2005 to 2014 (no ED data were available before 2005) from the New York State Statewide Planning and Research Cooperative System database.[16] A medically attended case of food-related anaphylaxis was defined as an inpatient hospitalization or an ED visit among NYC residents treated in an NYC hospital with a primary *ICD-9, Clinical Modification* (*ICD-9-CM*) diagnosis coded 995.60-995.69. These *ICD-9-CM* codes are consistent with those used in other published studies of food-related anaphylaxis hospitalizations[15,17,18] and include anaphylactic shock attributable to unspecified food (995.60) and 9 broad categories of specific foods, including 995.61 (peanuts), 995.62 (crustaceans), 995.63 (fruits and vegetables), 995.64 (tree nuts and seeds), 995.65 (fish), 995.66 (food additives), 995.67 (milk products), 995.68 (eggs), and 995.69 (other specific food). Patients admitted to the same hospital after ED discharge and patients admitted to a different hospital after ED discharge on the same day were de-duplicated.

Statistical analysis

Deaths were examined by demographic features, implicated food item, and other exposure categories. We defined 2 categories of potentially preventable deaths. These included public health preventable, defined as deaths that occurred from exposure in a restaurant or other public setting where an available epinephrine autoinjector might have been lifesaving. The second category was medically preventable, defined as deaths among persons who had a previously known allergy to the food leading to fatal anaphylaxis for whom a prescription of an autoinjector might have been lifesaving. As a surrogate for the risk of death among persons with anaphylaxis who required emergency medical attention, we calculated the ratio of deaths to the total number of hospitalizations plus ED visits.

Hospitalization and ED visit rates were calculated and categorized overall and by age group (0-4, 5-17, 18-34, 35-64, and ≥65 years), sex, causative allergen category with peanuts as the reference group, and period (2000-2003, 2004-2010, and 2011-2014). Periods selected for analysis were derived on the basis of when NYC started supplying epinephrine autoinjectors to schools (2004) and when national guidelines for prevention of anaphylaxis in schools were published (2010).[4,7] For ED visits, 2 periods were analyzed, 2005 to 2010 and 2011 to 2014, because there were no ED visit data before 2005. Rates were age-adjusted using direct standardization based on US Census Bureau 2000 data[19] or stratified by age group and expressed as the number of anaphylaxis events per 1 000 000 person-years. Nonoverlapping confidence intervals (CIs) were used to determine whether rates were different between groups. Analyses were performed using SAS 9.2 (SAS Institute Inc, Cary, North Carolina).

This study was deemed exempt from human subjects research by the institutional review boards at the Centers for Disease Control and Prevention and the New York City Department of Health and Mental Hygiene.

Results

During the study period, there were 24 deaths, 3049 hospitalizations, and 4013 ED visits not resulting in hospitalization among NYC residents attributable to food-related anaphylaxis (Table 1). Age-adjusted rates for hospitalizations were 26.2/1 000 000 person-years (95% CI = 25.4-27.0) and 50.9/1 000 000 person-years (95% CI = 49.5-52.3) for ED visits (Table 2).

The annualized rate of food-related anaphylaxis deaths per 10 million population was 2.0 (range: 0-6.1 deaths per 10 million population). Implicated foods in the deaths included crustaceans (7 deaths [29%]), peanuts (4 deaths [17%]), tree nuts or seeds (2 deaths [8%]), and fish (2 deaths [8%]) (Table 1). Other foods listed were milk, chickpeas, and chocolate (1 death each). The food exposure was not specified in 6 reports. Median age of decedents was 47 years (range: 6-84 years); risk for death was highest among people aged 65 years and older (2.1 deaths for every 100 hospitalizations and ED visits) and lowest among adults aged 18 to 34 years (0.1 deaths for every 100 hospitalizations and ED visits). All seafood-related deaths (crustaceans and fish) occurred among adults (aged ≥18 years) with a median age of 65 years. Of 7 deaths that occurred among children (aged <18 years), 4 were related to peanuts and tree nuts or seeds. Crustaceans had the highest allergen-specific risk for death at 1.8/100 hospitalizations, 6.5 times higher (95% CI = 1.9-22.1) than that for peanuts (Table 1).

Peanuts were the most common allergen implicated in hospitalizations (27.1%) and ED visits (20.2%). Age-adjusted rates of both hospitalizations and ED visits were highest for peanuts, followed by fish, and tree nuts and seeds (Table 2). Higher rates were most commonly associated with younger age (Table 3). Rates of hospitalizations for peanuts, tree nuts and seeds, milk products, and eggs were highest among persons aged 0 to 4 years; rates of hospitalizations for crustaceans and fish were highest among persons aged 5 to 17 years. Rates of ED visits for peanuts, tree nuts and seeds, milk products, and eggs were highest among persons aged 0 to 4 years; rates for crustaceans and fish showed less variation by age.

Rates of hospitalizations increased from 16.5/1 000 000 person-years during 2000 to 2003 to 34.0/1 000 000 during 2011 to 2014. Emergency department visit rates increased from 35.6/1 000 000 person-years during 2005 to 2010 to 73.8/1 000 000 during 2011 to 2014. Across the 3 periods, rates of hospitalizations increased for events related to peanuts, crustaceans, fruits and vegetables, tree nuts and seeds, and milk products (Table 4). Across the 2 periods with available ED data, ED visit rates increased for events linked to peanuts, crustaceans, fruits and vegetables, tree nuts and seeds, food additives, and milk products.

Epidemiology and potential preventability of deaths

Sixteen of 24 deaths were investigated by the medical examiner, including 5 crustacean-related cases, 2 peanut-related cases, and 1 seafood-related case. Of these, 11 (69% of 16 and 46% of all 24 deaths) were potentially preventable, including 2 public health preventable (1 nursing home and 1 restaurant), 5 medically preventable, and 4 medically and public health preventable (all 4 with restaurant exposure). Nine (56%) persons were known to be allergic to the implicated food they ingested; 3 had a known previous anaphylactic reaction. Two additional persons had previous less severe reactions, including 1 with hives and 1 with lip swelling. None had documentation that epinephrine was received at the time of the

TABLE 1
Deaths, Hospitalizations, and Emergency Department Visits From Food-Related Anaphylaxis, New York City, 2000-2014

	Number of Deaths (Column %)	Number of Hospitalizations (Column %)	Number of Emergency Department Visits[a] (Column %)	Ratio of Deaths to Hospitalizations and ED Visits per 100 Visits[b]
Total	24	3049	4013	0.3
Age, y				
0-4	0 (0.0)	557 (18.3)	809 (20.1)	
5-17	7 (29.2)	980 (32.1)	1235 (30.7)	0.3
18-34	2 (8.3)	467 (15.3)	1072 (26.6)	0.1
35-64	9 (37.5)	848 (27.8)	814 (20.2)	0.5
≥65	6 (25.0)	197 (6.5)	84 (2.1)	2.1
Sex				
Male	11 (45.8)	1465 (48.0)	2051 (50.9)	0.3
Female	13 (54.2)	1584 (52.0)	1963 (48.7)	0.4
Allergen (*ICD-9* code)				
Peanuts (995.61)	4 (16.7)	602 (19.7)	813 (20.2)	0.3
Crustaceans (995.62)	7 (29.2)	201 (6.6)	181 (4.5)	1.8
Fruits and vegetables (995.63)	0 (0.0)	252 (8.3)	267 (6.6)	...
Tree nuts and seeds (995.64)	2 (8.3)	296 (9.7)	427 (10.6)	0.3
Fish (995.65)	2 (8.3)	410 (13.4)	541 (13.4)	0.2
Food additives (995.66)	0 (0.0)	25 (0.8)	35 (0.9)	...
Milk products (995.67)	1 (4.2)	155 (5.1)	166 (4.1)	0.3
Eggs (995.68)	0 (0.0)	80 (2.6)	87 (2.2)	...
Other specific food (995.69)	2 (8.3)	826 (27.1)	882 (21.9)	0.1
Unspecified (995.60)	6 (25.0)	202 (6.6)	615 (15.3)	0.7
Study period				
2005-2010	13 (65.0)	1332 (55.8)	1694 (42.2)	0.4
2011-2014	7 (35.0)	1055 (44.2)	2320 (57.8)	0.2

Abbreviations: ED, emergency department; ICD-9, International Classification of Diseases, Ninth Revision.
[a] *Emergency department visits are 2005-2014.*
[b] *Numerator is the number of group-specific deaths. Denominator is the total number of group-specific hospitalizations plus group-specific ED visits.*

reaction before the arrival of medical personnel; only 1 was known to have an epinephrine autoinjector but did not have it at the time of exposure. Of the 5 restaurant exposures, 4 people were exposed to foods to which they knew they were allergic (2 to shrimp, 1 to lobster, and 1 to seafood). Of the 5 deaths that were not preventable, 4 occurred at home to people not known to be allergic to the suspect food, and 1 was a child with a known peanut allergy who died after peanut exposure at school despite being given a dose of epinephrine.

Discussion

This study is one of few population-based studies of food-related anaphylaxis deaths, ED visits, and hospitalizations in the United States and the only study from the perspective of a public health department. There are multiple findings relevant to the prevention of anaphylaxis deaths in NYC. First, the frequency and rate of deaths during the 15-year study period were low, averaging fewer than 2 deaths per year, with the absolute number per year lower in the most recent 4 years (2011-2014) compared with the preceding 7 years (2004-2010). This trend occurred in the context of an increasing frequency of hospitalizations and ED visits for anaphylaxis, an increase primarily driven by increases in hospitalizations and ED visits for peanut and other nut-related allergies. Second, higher numbers and rates of death occurred among adults than children. Deaths among adults were more often associated with crustacean ingestion than peanuts and other nuts, and the ratio of deaths to ED visits and hospitalizations was much higher for crustaceans than

TABLE 2

Age-Adjusted Hospitalization and Emergency Department Visit Rates of Food-Related Anaphylaxis by Causative Allergen, New York City, 2000-2014

	Hospitalizations (2000-2014)		Emergency Department Visits (2005-2014)	
	No.	Age-Adjusted Rate[a] per 1 000 000 Person-Years (95% CI)	No.	Age-Adjusted Rate[a] per 1 000 000 Person-Years (95% CI)
Overall	3049	26.2 (25.4-27.0)	4013	50.9 (49.5-52.3)
Peanuts	602	5.2 (4.8-5.6)	812	10.6 (9.9-11.3)
Crustaceans	201	1.7 (1.5-1.9)	181	2.2 (1.9-2.5)
Fruits and vegetables	252	2.1 (1.9-2.3)	267	3.3 (3.0-3.6)
Tree nuts and seeds	296	2.6 (2.3-2.9)	427	5.4 (4.9-5.9)
Fish	410	3.4 (3.1-3.7)	541	6.5 (6.0-7.0)
Food additives	25	0.2 (0.1-0.3)	35	0.5 (0.4-0.6)
Milk products	155	1.4 (1.1-1.7)	166	2.1 (1.6-2.6)
Eggs	80	0.7 (0.4-1.0)	87	1.1 (0.7-1.5)
Other specific food	826	7.1 (6.7-7.5)	882	11.2 (10.6-11.8)
Unspecified	202	1.8 (1.6-2.0)	615	7.9 (7.4-8.4)

Abbreviation: CI, confidence interval.

[a] Rates were calculated using New York City Department of Health and Mental Hygiene population estimates, modified from US Census Bureau vintage 2017 population estimates, and 95% CIs were estimated for a standard normal distribution. Rates were age-adjusted using the direct standardization method based on US Census Bureau 2000 data.

peanuts or nuts. Third, approximately half and possibly most deaths were preventable. Among deaths with sufficient information, most victims knew that they were allergic to the food they ingested but did not have an epinephrine autoinjector at the time of the reaction; approximately half ingested the suspect food in a public setting. Few did not know that they had a food allergy and were exposed at home where no immediate potential help was available; only 1 person was administered epinephrine before medical personnel arrived. These findings indicate that current prevention efforts directed at schools and day cares and emphasizing accidental nut exposure are working (ie, more public awareness and a lower threshold for seeking treatment of those with suspected reactions to peanuts and nuts). However, prevention efforts should also focus on prevention and treatment of anaphylactic reactions in adults, especially those with known crustacean or seafood allergies.

The low death rate reported in this study is consistent with those of other US studies using coded death data.[13-15] Two national studies examining trends in deaths from anaphylaxis during overlapping periods (1999-2009[15] and 1999-2010[14]) similarly found stable rates of food-related anaphylaxis. These other studies were unable to provide information about whether the statistically insignificant halving of the death rate in NYC since 2010 had occurred elsewhere. Food-related anaphylaxis deaths attributable to specific foods were not distinguished in these studies; thus, the relative importance of deaths from crustacean exposure compared with peanuts and other nuts was not reported.

In this study, trends in rates of hospitalizations and ED visits per 1 million population for food-related anaphylaxis were similar to those reported in 1 US national study covering 1999 to 2009.[15] Both studies reported increasing trends in food-related hospitalizations and ED visits overall and from major food allergens. In both studies, the leading causes and largest increases in hospitalizations and ED visits were from peanut and nut exposure. The relative exposures to peanuts and crustaceans among cases nationally were similar to those in NYC in comparable periods, with slightly higher prevalence of each nationally. Together, the national and NYC data support the hypothesis that increased public awareness that peanuts and nuts can cause fatal anaphylaxis has led to more people seeking treatment when they have a suspected allergic reaction.

Although case fatality rates were highest from crustacean exposure, rates of hospitalizations and ED visits were highest for peanut and other nut exposures. This is likely attributable to the national focus of prevention efforts on peanut and other nut exposures among children rather than anaphylaxis deaths among adults.[4,7] We found that approximately 50% to 70% of all deaths were potentially preventable; most were medically preventable because most involved persons with known food allergies who did

TABLE 3

Age-Stratified Hospitalization and Emergency Department Visit Rates of Food-Related Anaphylaxis by Causative Allergen, New York City, 2000-2014

	Hospitalizations (2000-2014)						Emergency Department Visits (2005-2014)					
	0-4 y		5-17 y		≥18 y		0-4 y		5-17 y		≥18 y	
	No.	Rate[a] per 1 000 000 Person-Years (95% CI)	No.	Rate[a] per 1 000 000 Person-Years (95% CI)	No.	Rate[a] per 1 000 000 Person-Years (95% CI)	No.	Rate[a] per 1 000 000 Person-Years (95% CI)	No.	Rate[a] per 1 000 000 Person-Years (95% CI)	No.	Rate[a] per 1 000 000 Person-Years (95% CI)
Overall	557	69.6 (63.8-75.4)	980	50.6 (47.4-53.8)	1512	15.9 (15.7-16.1)	809	151.7 (141.2-162.2	1234	98.3 (92.8-103.8)	1970	30.6 (30.3-30.9)
Allergen												
Peanuts	183	22.9 (19.6-26.2)	209	10.8 (9.3-12.3)	210	2.2 (2.1-2.3)	256	48.0 (42.1-53.9)	304	24.2 (21.5-26.9)	252	3.9 (3.8-4.0)
Crustaceans	[b]	[b]	68	3.5 (2.7-4.3)	129	1.4 (1.3-1.5)	[b]	[b]	52	4.1 (3-5.2)	125	1.9 (1.8-2.0)
Fruits and vegetables	18	2.2 (1.2-3.2)	50	2.6 (1.9-3.3)	184	1.9 (1.8-2.0)	28	5.3 (3.3-7.3)	68	5.4 (4.1-6.7)	171	2.7 (2.6-2.8)
Tree nuts and seeds	76	9.5 (7.4-11.6)	99	5.1 (4.1-6.1)	121	1.3 (1.2-1.4)	92	17.3 (13.8-20.8)	137	10.9 (9.1-12.7)	198	3.1 (3-3.2)
Fish	27	3.4 (2.1-4.7)	120	6.2 (5.1-7.3)	263	2.8 (2.7-2.9)	50	9.4 (6.8-12.0)	101	8 (6.4-9.6)	390	6.1 (6-6.2)
Food additives	[b]	[b]	[b]	[b]	12	0.1 (0.1-0.1)	[b]	[b]	16	1.3 (0.7-1.9)	14	0.2 (0.2-0.2)
Milk products	67	8.4 (6.4-10.4)	42	2.2 (1.5-2.9)	46	0.5 (0.5-0.5)	74	13.9 (10.7-17.1)	32	2.5 (1.6-3.4)	60	0.9 (0.8-1)
Eggs	48	6 (4.3-7.7)	[b]	[b]	23	0.2 (0.2-0.2)	53	9.9 (7.2-12.6)	17	1.4 (0.7-2.1)	17	0.3 (0.3-0.3)
Other specific food	101	12.6 (10.1-15.1)	298	15.4 (13.7-17.1)	427	4.5 (4.4-4.6)	122	22.9 (18.8-27.0)	289	23 (20.3-25.7)	471	7.3 (7.1-7.5)
Unspecified	28	3.5 (2.2-4.8)	77	4 (3.1-4.9)	97	1 (1.0-1.0)	125	23.4 (19.3-27.5)	218	17.4 (15.1-19.7)	272	4.2 (4.1-4.3)

Abbreviation: CI, confidence interval.

[a] *Rates were calculated using New York City Department of Health and Mental Hygiene population estimates, modified from US Census Bureau vintage 2017 population estimates, and 95% confidence intervals were estimated for a standard normal distribution.*

[b] *Numerator cell size is less than 10 and point estimate has been suppressed because of inadequate sample size.*

TABLE 4
Age-Adjusted Hospitalization and Emergency Department Visit Rates of Food-Related Anaphylaxis by Causative Allergen and Period, New York City, 2000-2014

	Hospitalizations						Emergency Department Visits			
	2000-2003		2004-2010		2011-2014		2005-2010		2011-2014	
	No.	Rate[a] per 1 000 000 Person-Years (95% CI)	No.	Rate[a] per 1 000 000 Person-Years (95% CI)	No.	Rate[a] per 1 000 000 Person-Years (95% CI)	No.	Rate[a] per 1 000 000 Person-Years (95% CI)	No.	Rate[a] per 1 000 000 Person-Years (95% CI)
Overall	517	16.5 (15.3-17.7)	1477	27.4 (26.2-28.6)	1055	34.0 (32.2-35.8)	1694	35.6 (34.0-37.2)	2319	73.8 (71.3-76.3)
Allergen										
Peanuts	76	2.4 (1.9-2.9)	302	5.7 (5.1-6.3)	224	7.4 (6.5-8.3)	305	6.6 (5.8-7.4)	507	16.6 (15.3-17.9)
Crustaceans	38	1.2 (1.0-1.4)	95	1.7 (1.4-2.0)	68	2.2 (1.8-2.6)	81	1.7 (1.4-2.0)	100	3.0 (2.5-3.5)
Fruits and vegetables	44	1.4 (1.0-1.8)	126	2.3 (2.0-2.6)	82	2.5 (2.0-3.0)	128	2.6 (2.2-3.0)	139	4.3 (3.7-4.9)
Tree nuts and seeds	38	1.2 (0.8-1.6)	136	2.6 (2.2-3.0)	122	4.0 (3.4-4.6)	135	2.9 (2.4-3.4)	292	9.2 (8.3-10.1)
Fish	93	3.0 (2.5-3.5)	201	3.7 (3.3-4.1)	116	3.5 (2.9-4.1)	305	6.1 (5.4-6.8)	236	7.2 (6.4-8.0)
Food additives	[b]	[b]	14	0.3 (0.2-0.4)	[b]	[b]	11	0.2 (0.1-0.3)	24	0.8 (0.6-1.0)
Milk products	27	0.9 (0.6-1.2)	63	1.2 (0.9-1.5)	65	2.1 (1.3-2.9)	70	1.5 (1.0-2.0)	96	3.0 (2.1-3.9)
Eggs	17	0.5 (0.1-0.9)	35	0.6 (0.1-1.1)	28	0.9 (0.1-1.7)	31	0.7 (0.1-1.3)	56	1.8 (1.0-2.6)
Other specific food	138	4.4 (3.8-5.0)	402	7.5 (6.9-8.1)	286	9.3 (8.5-10.1)	404	8.6 (7.9-9.3)	478	15.1 (14.1-16.1)
Unspecified	43	1.4 (1.0-1.8)	103	2.0 (1.7-2.3)	56	1.9 (1.6-2.2)	224	4.8 (4.2-5.4)	391	12.7 (11.7-13.7)

Abbreviation: CI, confidence interval.

[a] *Rates were calculated using New York City Department of Health and Mental Hygiene population estimates, modified from US Census Bureau vintage 2017 population estimates, and 95% confidence intervals were estimated for a standard normal distribution.*

[b] *Numerator cell size is less than 10 and point estimate has been suppressed because of inadequate sample size.*

not carry an epinephrine autoinjector. Multiple deaths occurred in public settings (eg, restaurant or nursing home) among persons without known food allergies and might have been preventable had there been epinephrine autoinjectors on-site.

The public health effort to prevent anaphylaxis deaths in the United States has primarily focused on several areas that include (1) increasing public awareness of possible food allergens in packaged food (ie, labeling); (2) increasing public and food service establishment workers' awareness of possible food allergens in food prepared and served in licensed food establishments; and (3) making epinephrine autoinjectors available in schools and day care centers.[4,7,8] The findings from our study have several additional implications for NYC and possibly other jurisdictions that include (1) improvements in alerting clinicians and the public to the need for adults with allergies to the most common causes of anaphylaxis, to avoid those foods, and to be prescribed and carry an epinephrine autoinjector whenever eating is anticipated; and (2) potential benefit to having undesignated epinephrine autoinjectors available in public places where food is served, especially licensed food service establishments. The latter has been receiving growing attention in parts of the United States with a bill passed that facilitates this on a voluntary basis in Florida.[10] Also, bills were introduced in 2 states that required restaurants to have an epinephrine autoinjector on hand,[11,12] but neither bill passed. Finally, a recent white paper was published that addressed concerns and possible solutions.[8] A barrier to wider availability of epinephrine autoinjectors is cost. The retail price can be as high as $700, out of range of the $24 estimated by others[20] that could make personal autoinjectors cost-effective in preventing peanut-related deaths in children. Also, requiring nondesignated epinephrine autoinjectors be made widely available in food service establishments would be an educational challenge. At a minimum, it would require both recognition on the victim's part that he or she might be having an anaphylactic reaction and that an epinephrine injection was needed immediately, and that the person who administered epinephrine would do so correctly. An educational effort targeted at food service establishments would also need to include posting information on the menu or another prominent place that an epinephrine autoinjector is available.

Limitations

This study has multiple limitations. First, detailed information on circumstances of death was available only for 16 of 24 people, but even that information was not systematically collected. Developing guidelines for those who investigate and certify deaths could improve the quality and standardization of information collected. Second, a substantial percentage of hospital and ED discharge diagnoses for food-related anaphylaxis specified no particular food item. The likelihood exists that the percentages of specific food items are higher than presented. Third, incidence rates for hospital and ED discharges and deaths are likely underestimates of the true burden of food-related anaphylaxis, because anaphylactic reactions can mimic other signs and symptoms (eg, asthma, cardiac events, and shock). Furthermore, only the principal discharge diagnosis was used to classify hospitalizations and ED visits; events may have been indicated in a secondary diagnosis. Fourth, this study cannot shed light on the possible preventability of hospitalizations and ED visits for food-related anaphylaxis among survivors as data on setting of exposure and timing to treatment were not readily available. Finally, data are specific to NYC. Other public health agencies are encouraged to conduct their own analyses of death, hospitalization, and ED data to determine where there might be opportunities to prevent the limited number of deaths per year from food-related anaphylaxis.

Implications for Policy & Practice

- Current efforts to prevent deaths from food-related anaphylaxis in children, including education in school and day care settings and ensuring epinephrine autoinjector availability on-site, appear to be effective.
- Current efforts to prevent such deaths in adults need enhancing. Most deaths from food-related anaphylaxis in New York City occurred in adults who ingested a food to which they knew they were allergic, especially crustaceans, and did not have an epinephrine autoinjector available.
- More attention needs to be paid to ensuring that adults with potentially life-threatening food allergies have a strict plan to avoid those foods, are prescribed an epinephrine autoinjector, carry it with them at all times when eating is anticipated, and know the indications for using it.
- Deaths from food-related anaphylaxis are rare. Given the large number of food service establishments and high cost of epinephrine autoinjectors, it might not be feasible for public health agencies to make epinephrine autoinjectors available in public places other than schools and day care centers, except voluntarily and as permitted by local law.
- Other public health agencies are encouraged to conduct their own analyses of death and hospital and ED discharge data to determine where there might be opportunities to prevent deaths from food-related anaphylaxis.

Conclusions

Deaths from food-related anaphylaxis are rare. In NYC, adults are at much higher risk than children for whom prevention efforts centered on peanuts and other nuts appear to be effective. At least half of fatal reactions in adults might have been prevented among those with known food allergies. This is especially true for deaths that involved crustaceans. By having and adhering to a strict plan to avoid those foods, recognizing symptoms of anaphylaxis, and having immediate access to epinephrine autoinjectors, these deaths might have been averted. Clinicians need to assure adults and children with food allergies to take food allergies seriously, avoid foods to known allergens, and carry a prescribed up-to-date epinephrine autoinjector. Given the low incidence of food-related fatalities and the high cost of epinephrine autoinjectors, it might not be feasible for public health agencies to make epinephrine autoinjectors available in public places other than schools and day care centers, except voluntarily and as permitted by local law.

References

1. Branum AM, Lukacs SL. Food allergy among children in the United States. *Pediatrics*. 2009;124(6):1549-1555.
2. Decker WW, Campbell RL, Manivannan V, et al. The etiology and incidence of anaphylaxis in Rochester, Minnesota: a report from the Rochester Epidemiology Project. *J Allergy Clin Immunol*. 2008;122:1161-1165.
3. McGowan EC, Keet CA. Prevalence of self-reported food allergy in the National Health and Nutrition Examination Survey (NHANES) 2007-2010. *J Allergy Clin Immunol*. 2013;132:1216-1219.
4. Sicherer SH, Mahr T; American Academy of Pediatrics Section on Allergy and Immunology. Management of food allergy in the school setting. *Pediatrics*. 2010;126(6):1232-1239.
5. Simons FE, Ardusso LR, Bilo MB, et al. World allergy organization guidelines for the assessment and management of anaphylaxis. *World Allergy Organ J*. 2011;4:13-37.
6. FAIR Health. Food allergy in the United States: recent trends and costs. An analysis of private claims data. A FAIR Health Whitepaper. https://s3.amazonaws.com/media2.fairhealth.org/whitepaper/asset/Food%20Allergy%20White%20Paper%20Final.compressed.pdf. Published 2017. Accessed October 22, 2019.
7. Centers for Disease Control and Prevention. *Voluntary Guidelines for Managing Food Allergies in Schools and Early Care and Education Programs*. Washington, DC: US Department of Health & Human Services; 2013.
8. National Academy of Sciences, Engineering and Medicine. Chapter 8. *Finding a Path to Safety in Food Allergy: Assessment of the Global Burden, Causes, Prevention, Management and Public Policy*. Washington, DC: The National Academic Press; 2017:333-364.
9. Chapter 27 of Title 24 of The Rules of The City of New York. Food allergy information. https://www1.nyc.gov/assets/doh/downloads/pdf/about/healthcode/health-code-chapter27.pdf. Published 2009. Accessed October 22, 2019.
10. Florida Senate. CS/CS/HB 1131: emergency allergy treatment. https://www.flsenate.gov/session/Bill/2014/1131. Published 2014. Accessed October 22, 2019.
11. New York State Senate. Senate Bill S38. An act to amend the public health law, in relation to requiring the presence of epinephrine autoinjector devices on pre-school premises and on restaurant premises. https://www.nysenate.gov/legislation/bills/2015/s38. Published 2015. Accessed October 22, 2019.
12. State of New Jersey 218 Legislature. An act concerning emergency epinephrine administration at restaurants, and supplementing Title 26 of the Revised Statutes. https://www.njleg.state.nj.us/2018/Bills/A1500/1206_I1.htm. Published 2018. Accessed October 22, 2019.
13. Simon MR, Mulla ZD. A population-based epidemiologic analysis of deaths from anaphylaxis in Florida. *Allergy*. 2008;63:1077-1083.
14. Jerschow E, Lin RY, Scaperotti MM, McGinn AP. Fatal anaphylaxis in the United States 1999-2010: temporal patterns and demographic associations. *J Allergy Clin Immunol*. 2014;134(6):1318-1328. e7.
15. Ma L, Danoff TM, Borish L. Case fatality and population mortality associated with anaphylaxis in the United States. *J Allergy Clin Immunol*. 2014;133:1075-1083.
16. New York State Department of Health. Statewide Planning and Research Cooperative System (SPARCS), 2000-2014. https://www.health.ny.gov/statistics/sparcs/. Accessed October 22, 2019.
17. Mulla ZD, Simon MR. Hospitalizations for anaphylaxis in Florida: epidemiologic analysis of a population-based dataset. *Int Arch Allergy Immunol*. 2007;144(2):128-136.
18. Mulla ZD. Hospitalizations of children and young adults from peanut-induced anaphylaxis in Texas. *South Med J*. 2011;104:322-324.
19. Klein RJ, Schoenborn CA. *Age Adjustment Using the 2000 Projected U.S. Population*. Healthy People Statistical Notes, no. 20. Hyattsville, MD: National Center for Health Statistics. https://www.cdc.gov/nchs/data/statnt/statnt20.pdf. Published 2001. Accessed October 22, 2019.
20. Shaker M, Geenhaw M. Association of fatality risk with value-based drug pricing of epinephrine autoinjectors for children with peanut allergy, a cost-effectiveness analysis. *JAMA Netw Open*. 2018;1(7):e184728.