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PEDIATRIC ANAPHYLAXIS IN THE PREHOSPITAL SETTING: INCIDENCE, CHARACTERISTICS, AND MANAGEMENT

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ABSTRACT

Objective: Although hospital presentations for pediatric anaphylaxis have been described in the literature, a minimal amount is known regarding the incidence, characteristics, and management of pediatric anaphylaxis presenting to emergency medical services (EMS). **Methods:** We performed a retrospective observational study of pediatrics (≤ 16 years) presenting to EMS in Victoria, Australia. Patients with suspected anaphylaxis were included if they were treated with epinephrine before or after EMS arrival. We used descriptive statistics to compare baseline characteristics and linear regression to assess trends in incidence over time. **Results:** Between July 2008 and June 2016, we identified 2,137 pediatric anaphylaxis presentations. Overall, 59% were male and 70% had pre-existing anaphylaxis. The age-adjusted incidence increased over the study period, from 11.8 presentations per 100,000 person-years in 2008–09 to 38.7 in 2015–16 (p for trend < 0.001). Common suspected allergens included nuts (52%) and dairy/milk formula (17%). In total, 1,333 (62%) patients received epinephrine via an autoinjector, and 51 (2%) from a doctor before EMS arrival. When compared to patients receiving epinephrine after EMS arrival, patients treated prior were more likely to present with vital signs within normal limits, including heart rate (66% vs. 84%, $p < 0.001$), systolic blood

pressure (77% vs. 93%, $p < 0.001$) and respiratory rate (79% vs. 91%, $p < 0.001$). The most common EMS interventions were intramuscular epinephrine (45%) and inhaled salbutamol (14%). Three out-of-hospital cardiac arrests were observed, two of whom received endotracheal intubation. **Conclusion:** The incidence of prehospital pediatric anaphylaxis is increasing significantly. Despite this, most patients are hemodynamically stable on presentation and few require emergency treatments beyond the administration of intramuscular epinephrine. **Key words:** anaphylaxis; emergency medical services; emergency treatment; pediatrics

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INTRODUCTION

Anaphylaxis is an acute, potentially life-threatening, systemic hypersensitivity reaction that is characterized by bronchospasm, upper airway angioedema and/or circulatory compromise (1). Anaphylaxis in both adults and pediatrics is relatively uncommon, although its incidence is increasing in developed countries (2). In particular, the incidence of pediatric anaphylaxis, especially from food-related triggers, is increasing in Australia (3), the United Kingdom (4), and North America (5).

As anaphylaxis is rapid onset and can lead to cardiorespiratory arrest within minutes, public education campaigns have focused on the importance of recognizing symptoms early, activating emergency medical services (EMS) and initiating treatment with an epinephrine autoinjector (6). Unfortunately, there is a minimal amount of published data describing the prevalence, characteristics, and emergency treatment of pediatric anaphylaxis in the prehospital setting (7–10). In particular, rates of autoinjector prescription and self-administration are seldom reported, and relatively few studies have described the frequency of EMS-initiated interventions in these populations. Although most systems authorize EMS personnel to administer intramuscular epinephrine for the initial management of anaphylaxis (11), treatment with adjunct therapies such as inhaled bronchodilators, intravenous epinephrine, and endotracheal intubation are not well described (9,10).

In this report, we describe the incidence, characteristics, and emergency management of pediatric anaphylaxis cases presenting to EMS over an eight-year period.

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Supplemental data for this article can be accessed on the [publisher's website](#).

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METHODS

Study Design

This retrospective observational study included pediatric patients aged ≤ 16 years attended by EMS between July 1, 2008 and June 30, 2016 in whom there was suspected anaphylaxis. Patients were included if: 1) they received EMS treatment with epinephrine or 2) received treatment with epinephrine prior to EMS arrival (e.g. self-treatment with autoinjector). The study was approved by Monash University Human Research Ethics Committee.

Setting

The study was conducted in the state of Victoria, Australia, with a population of more than six million people across 227,000 square kilometers. Ambulance Victoria is the state-wide provider of EMS. The EMS utilizes the Medical Priority Dispatch System to triage emergency calls, and Advanced Life Support and Intensive Care paramedics are dispatched to medical emergencies in a two-tiered fashion. Clinical practice guidelines authorize all paramedics to administer intramuscular epinephrine (10 mcg/kg) for pediatric anaphylaxis, with the addition of inhaled bronchodilators and/or epinephrine according to clinical need. According to the clinical practice guideline, epinephrine in the setting of anaphylaxis may be administered to patients with a sudden onset of two or more of: respiratory distress, abdominal symptoms, skin/mucosal symptoms, or hypotension. Patients with isolated hypotension and exposure to a known allergen are also indicated to receive epinephrine. Intensive Care paramedics are also authorized to perform endotracheal intubation and administer intravenous therapy (including epinephrine, crystalloid fluid, and corticosteroids), as indicated.

Data Source and Definitions

Data for this study were sourced from the Ambulance Victoria data warehouse. Data from electronic patient care records, which are completed by paramedics at the conclusion of each case, are uploaded wirelessly into the data warehouse (12). Patients included in this study were identified through an electronic search strategy, including: patient age ≤ 16 years, clinical assessment of anaphylaxis or allergic reaction, paramedic treatment with epinephrine, or prior care management with epinephrine (i.e., before EMS arrival). To ensure cases were not missed, we also conducted a word search of case histories to identify any additional patients who may have received epinephrine before EMS arrival, such as those presenting to general practitioners (family physician), first-aiders, or teachers.

For all included cases, we extracted demographic and clinical data (e.g., age, sex, location, prior care, paramedic interventions, and vital signs). The Victorian Ambulance Cardiac Arrest Registry (VACAR) was used to identify and describe patients with out-of-hospital cardiac arrest (13). Age-specific vital sign observations, including pulse rate, respiratory rate, and systolic blood pressure, were defined according to a report by Bonafide and colleagues (14). Low, normal, and high categories were defined as less than the 5th percentile, between the 5th and 95th percentile and above the 95th percentile for age-specific observations, respectively (see supplementary Table S1).

Statistical Analyses

All analyses were conducted using Stata Statistical Software: Release 14 (College Station, Texas, USA: StataCorp LP). A two-sided p -value < 0.05 was considered statistically significant for all tests. Data are presented as frequencies and proportions and stratified by age groups. Differences in demographic and clinical variables across age groups were assessed using the χ^2 test. In addition, we compared the baseline vital signs of patients who were treated by EMS with those that were treated before EMS arrival using the χ^2 test.

We calculated the age-adjusted incidence of pediatric anaphylaxis-related EMS presentation using population estimates from the Australian Bureau of Statistics (15). Age-standardization was performed using the relevant year's Victorian population and the population in 2001 as the standard population. We also calculated age-specific rates for pediatric anaphylaxis, and age-adjusted incidence of epinephrine administration before and after EMS arrival. To assess trends in incidence over time we used simple linear regression. Due to the use of paper rather than electronic patient care records between October and December 2014, the number of cases recorded was lower than expected during this period. To account for this missing data, we inflated incidence estimates for the 2014–15 financial year by 25% based on the expected number of observations in the affected period.

RESULTS

A total of 335,692 pediatric patients were attended by EMS during the study period, of which 10,580 (3.2%) were localized allergy or anaphylaxis-related presentations. Of these, 2,137 (20.2%) patients received emergency treatment with epinephrine either before or after EMS arrival (see Figure S1 in the supplementary appendix).

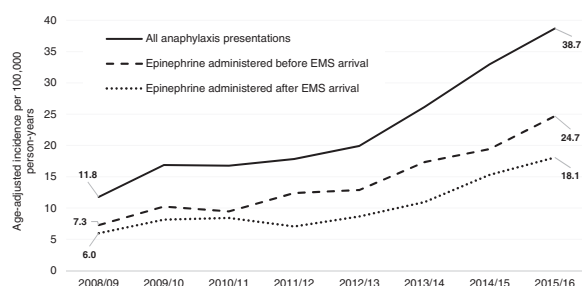


FIGURE 1. Age-adjusted incidence of pediatric anaphylaxis presentations across the study period (p for trend < 0.01 for all categories).

Incidence of Pediatric Anaphylaxis

The age-adjusted and age-specific incidence of anaphylaxis-related presentations is shown in Figure 1 and Figure 2, respectively. Overall, the age-adjusted incidence of anaphylaxis-related presentations increased over the study period, from 11.8 presentations per 100,000 person-years in 2008–09 to 38.7 presentations per 100,000 person-years in 2015–16 (p for trend < 0.001). Over the same time period, the age-adjusted incidence of epinephrine administration prior to EMS arrival also increased from 7.3 to 24.7 presentations per 100,000 person-years (p for trend < 0.001). Age-specific incidence rates also increased 19-fold for patients aged < 12 months, 3-fold for patients aged 1 to 4 and 5 to 11 years, and 4-fold for patients aged 12 to 16 years.

Baseline Characteristics

Baseline characteristics are presented across age categories in Table 1. Overall, most patients were male (59%), however the proportion of male patients decreased with increasing age. A total of 70% of patients were recorded as having pre-existing anaphylaxis, and this increased with increasing age ($p < 0.001$), while 90% were reported as having pre-existing allergies. In total, 65% of patients were recorded as having an epinephrine autoinjector prescribed by a doctor, and this also increased with increasing age ($p < 0.001$). Of the patients who were recorded as having existing

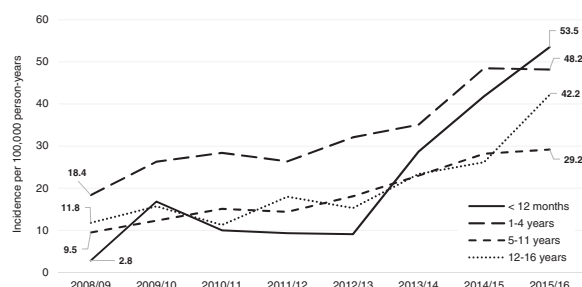


FIGURE 2. Age-specific incidence across the study period (p for trend < 0.01 for all categories).

allergies and an autoinjector prescribed by a doctor ($n = 1,387$), 110 (8%) did not have the autoinjector administered prior to EMS arrival.

Most cases occurred in the home (60%), although this decreased with increasing age ($p < 0.001$). In total, 13% of cases occurred at school. In 92% of cases, the allergic reaction was identified by the emergency call-taker, and 98% were transported to hospital. Of the 40 patients not transported by EMS, 15 (38%) refused transport, 12 (30%) were discharged at scene, and 10 (25%) were transported by other means.

Suspected allergens are presented in Table 2. Common allergens included nuts (52%), dairy or baby milk formula (17%), and eggs (14%). Exercise-induced anaphylaxis was identified among 8% of patients aged 12–16 years.

Clinical Observations

Clinical observations of included patients are presented in Table 3. The most common symptoms were urticaria/rash and swelling/angioedema (69% for both). The majority of patients presented with vital signs within normal limits on EMS arrival, including systolic blood pressure (87%), respiratory rate (86%), and oxygen saturation (87%). Less than one quarter presented with tachycardia (22%), and this decreased with increasing age ($p < 0.001$). Three out-of-hospital cardiac arrests were observed; two were witnessed by EMS and two survived to hospital discharge.

Initial vital sign observations according to whether epinephrine was administered before or after EMS arrival are shown in Table 4. When compared to patients receiving epinephrine after EMS arrival, patients receiving epinephrine before EMS arrival were more likely to present with vital signs within the normal ranges, including: heart rate (66% vs. 84%, $p < 0.001$), systolic blood pressure (77% vs 93%, $p < 0.001$), respiratory rate (79% vs. 91%, $p < 0.001$), and oxygen saturation (76% vs. 95%, $p < 0.001$).

Prehospital Interventions

Prehospital interventions performed across age categories are presented in Table 5. In total, 62% of patients had an autoinjector administered prior to EMS arrival, and an additional 2% received epinephrine from a family physician. Intramuscular epinephrine was administered by paramedics to 45% of patients, and 8% received epinephrine both before and after EMS arrival. Of the 110 patients with an autoinjector prescribed but for whom it was not administered prior to EMS arrival, 109 were administered epinephrine by EMS.

Inhaled salbutamol was administered in 14% of patients. Intravenous and inhaled epinephrine, intravenous crystalloid and endotracheal intubation were

TABLE 1. Baseline characteristics of pediatric anaphylaxis presentations stratified by age category

	Overall (n = 2,137)	≤12 months (n = 127)	1–4 years (n = 756)	5–11 years (n = 711)	12–16 years (n = 543)	p-value
Male gender, n (%)	1264 (59.2)	91 (71.7)	515 (68.2)	440 (61.9)	218 (40.2)	<0.001
Scene location, n (%)						
Private residence	1275 (59.7)	101 (79.5)	507 (67.1)	427 (60.1)	240 (44.2)	<0.001
School	274 (12.8)	0	36 (4.8)	110 (15.5)	128 (23.6)	<0.001
Public location	256 (12.0)	5 (3.9)	72 (9.5)	78 (11.0)	101 (18.6)	<0.001
Hospital / clinic	254 (11.9)	18 (14.2)	100 (13.2)	79 (11.1)	57 (10.5)	0.3
Other	78 (3.7)	3 (2.4)	41 (5.4)	17 (2.4)	17 (3.1)	0.012
Pre-existing anaphylaxis, n (%)	1310 (70.0)	18 (20.2)	423 (66.2)	485 (74.4)	384 (78.2)	<0.001
Pre-existing allergies, n (%)	1776 (94.5)	47 (67.1)	610 (92.9)	632 (96.9)	487 (97.2)	<0.001
Autoinjector prescribed, n (%)	1387 (64.9)	14 (11.0)	441 (58.3)	523 (73.6)	409 (75.3)	<0.001
Allergic reaction identified in emergency call, n (%)	1963 (91.9)	112 (88.2)	699 (92.5)	668 (94.0)	484 (89.1)	0.007
Transported to hospital, n (%)	2097 (98.1)	127 (100)	743 (98.3)	693 (97.5)	534 (98.3)	0.2

Proportions exclude missing data.

initiated infrequently. Of the three patients suffering an out-of-hospital cardiac arrest, all had epinephrine administered before and after EMS arrival and two received intravenous epinephrine.

A total of two patients underwent endotracheal intubation during the study period, and both were out-of-hospital cardiac arrest patients.

DISCUSSION

To our knowledge, this is the largest collection of data involving pediatric anaphylaxis presentations in the prehospital setting. Our study shows that the incidence of prehospital pediatric anaphylaxis has increased three-fold over an 8-year period. The majority of pediatric anaphylaxis presentations were relatively uncomplicated, with few patients requiring adjunct therapies beyond the administration of intramuscular epinephrine. Importantly, anaphylactic shock that required intravenous epinephrine, respiratory failure requiring intubation, and/or cardiac arrest was rare in our population.

Our work contributes to a growing body of evidence that shows that hospital presentations for pediatric anaphylaxis are on the rise in developed countries. A previous study from Australia reported a four-fold increase in hospital admission rates for pediatric anaphylaxis between 1998 and 2012 (3). Similarly, a report from the United Kingdom found that hospital admissions for food-related anaphylaxis increased by 137% in patients aged less than 15 years over a 20 year period (4). In the prehospital setting, EMS exposure to pediatric anaphylaxis is infrequent. One report from the United States, involving 11 counties with a population of approximately 13 million people, reported that 0.5% of EMS presentations in pediatrics were due to anaphylaxis (16). Another North American study reported 0.04% of all cases, not limited to pediatrics, to involve anaphylaxis (17). In our study, pediatric patients with anaphylaxis requiring epinephrine therapy comprised 0.6% of all pediatric presentations.

Long-term trends in EMS attendance to anaphylaxis have been poorly described, and therefore our study is among the first to report an increase in EMS attendance

TABLE 2. Suspected allergens stratified by age category

	Overall (n = 2,137)	≤12 months (n = 127)	1–4 years (n = 756)	5–11 years (n = 711)	12–16 years (n = 543)	p-value
Suspected allergen, n (%)*						
Nuts	929 (52.0)	37 (31.9)	339 (53.3)	332 (55.5)	221 (50.7)	<0.001
Eggs	241 (13.5)	44 (37.9)	125 (19.7)	58 (9.7)	14 (3.2)	<0.001
Dairy / Milk formula	297 (16.6)	35 (30.2)	136 (21.4)	97 (16.2)	29 (6.7)	<0.001
Chocolate	108 (6.1)	0	32 (5.0)	53 (8.9)	23 (5.3)	0.001
Fruit / vegetables	71 (4.0)	6 (5.2)	21 (3.3)	28 (4.7)	16 (3.7)	0.6
Seafood / meat	114 (6.4)	3 (2.6)	39 (6.1)	40 (6.7)	32 (7.3)	0.3
Other food / unspecified food	446 (25.0)	27 (23.3)	169 (26.6)	145 (24.3)	105 (24.1)	0.7
Insect / animal	218 (12.2)	7 (6.0)	65 (10.2)	80 (13.4)	66 (15.1)	0.013
Grass / plant	34 (1.9)	0	2 (0.3)	13 (2.2)	19 (4.4)	<0.001
Medication / other chemical substance	88 (4.9)	5 (4.3)	26 (4.1)	24 (4.0)	33 (7.6)	0.035
Exercise	51 (2.9)	0	2 (0.3)	15 (2.5)	34 (7.8)	<0.001
Unknown allergen	352	11	120	113	108	—

Proportions exclude missing data.

*Patients may fall into >1 category and proportions will not add to 100%.

TABLE 3. Clinical observations in pediatric anaphylaxis presentations stratified by age category

	Overall (n = 2,137)	≤12 months (n = 127)	1–4 years (n = 756)	5–11 years (n = 711)	12–16 years (n = 543)	p-value
Main symptoms, n (%)*						
Swelling / angioedema	1483 (69.4)	93 (73.2)	549 (72.6)	466 (65.6)	375 (69.1)	0.025
Rash / urticaria	1480 (69.3)	117 (92.1)	587 (77.7)	434 (61.1)	342 (63.0)	<0.001
Breathing difficulty	1007 (47.1)	42 (33.1)	397 (52.5)	340 (47.9)	228 (42.0)	<0.001
Vomiting / diarrhea	857 (40.1)	62 (48.8)	310 (41.0)	286 (40.3)	199 (36.7)	0.07
Missing	1	0	0	1	0	—
Pulse rate, n (%)**						
Bradycardia	12 (0.6)	0	7 (1.0)	4 (0.6)	1 (0.2)	0.3
Normal	1636 (77.5)	79 (63.7)	534 (72.2)	590 (83.7)	433 (79.9)	<0.001
Tachycardia	463 (21.9)	45 (36.3)	199 (26.9)	111 (15.7)	108 (19.9)	<0.001
Missing	26	3	16	6	1	—
Systolic blood pressure, n (%)**						
Normal	1509 (86.8)	50 (86.2)	404 (85.1)	587 (88.3)	468 (86.5)	0.5
Hypotensive	230 (13.2)	8 (13.8)	71 (15.0)	78 (11.7)	73 (13.5)	0.5
Missing	398	69	281	46	2	—
Oxygen saturation, n (%)						
≤89%	83 (5.3)	6 (7.4)	29 (5.5)	28 (5.2)	20 (4.7)	0.8
90–93%	115 (7.3)	8 (9.9)	53 (10.1)	35 (6.5)	19 (4.5)	0.006
≥94%	1372 (87.4)	67 (82.7)	443 (84.4)	474 (88.3)	388 (90.9)	0.012
Missing	567	46	231	174	116	—
Respiratory rate, n (%)**						
Bradypnea	47 (2.2)	8 (6.5)	21 (2.9)	8 (1.1)	10 (1.9)	0.001
Normal	1816 (86.2)	93 (75.6)	644 (87.5)	624 (88.5)	455 (84.0)	<0.001
Tachypnea	243 (11.5)	22 (17.9)	71 (9.7)	73 (10.4)	77 (14.2)	0.007
Missing	31	4	20	6	1	—
GCS, n (%)						
15	1890 (88.9)	89 (70.6)	598 (79.7)	677 (95.6)	526 (96.9)	<0.001
≤14	237 (11.1)	37 (29.4)	152 (20.3)	31 (4.4)	17 (3.1)	<0.001
Missing	10	1	6	3	0	—
Out-of-hospital cardiac arrest, n (%)	3 (0.1)	0	0	1 (0.1)	2 (0.4)	0.4

Proportions exclude missing data.

*Patients may fall into >1 category and proportions will not add to 100%.

**Age-specific “normal” ranges used. Abbreviation: GCS = Glasgow Coma Score.

TABLE 4. Initial vital sign observations according to whether epinephrine was administered before or after EMS arrival

	Epinephrine before EMS arrival (n = 1333)	Epinephrine after EMS arrival (n = 804)	p-value
Pulse rate, n (%)*			
Bradycardia	10 (0.8)	2 (0.3)	0.1
Normocardia	1106 (84.2)	530 (66.4)	<0.001
Tachycardia	197 (15.0)	266 (33.3)	<0.001
Missing	20	6	—
Systolic blood pressure, n (%)*			
Normotension	1017 (92.7)	492 (76.6)	<0.001
Hypotension	80 (7.3)	150 (23.4)	<0.001
Missing	236	162	—
Respiratory rate, n (%)*			
Bradypnea	29 (2.2)	18 (2.3)	0.9
Normopnea	1186 (90.5)	630 (79.2)	<0.001
Tachypnea	95 (7.3)	148 (18.6)	<0.001
Missing	23	8	—
Oxygen saturation, n (%)			
≤89%	21 (2.2)	62 (10.5)	<0.001
90–93%	32 (3.3)	83 (14.0)	<0.001
≥94%	924 (94.6)	448 (75.6)	<0.001
Missing	356	211	—
GCS, n (%)			
15	1257 (94.9)	633 (78.8)	<0.001
≤14	67 (5.1)	170 (21.2)	<0.001
Missing	9	1	—

Proportions exclude missing data.

*Age-specific “normal” ranges used. Abbreviation: GCS = Glasgow Coma Score.

TABLE 5. Prehospital interventions performed for anaphylaxis-related presentations

	Overall (n = 2,137)	≤12 months (n = 127)	1–4 years (n = 756)	5–11 years (n = 711)	12–16 years (n = 543)	p-value
Before EMS arrival, n (%)						
Epinephrine administered by Doctor	51 (2.4)	4 (3.2)	21 (2.8)	19 (2.7)	7 (1.3)	0.3
Autoinjector administered	1333 (62.4)	17 (13.4)	428 (56.6)	507 (71.3)	381 (70.2)	<0.001
EMS response time (mins), median (IQR)	10 (8–14)	10 (8–14)	10 (7–14)	11 (8–15)	10 (8–14)	0.08
After EMS arrival, n (%)						
IM epinephrine	964 (45.1)	109 (85.8)	379 (50.1)	251 (35.3)	225 (41.4)	<0.001
IM epinephrine after autoinjector use	176 (8.2)	1 (0.8)	56 (7.4)	53 (7.5)	66 (12.2)	<0.001
IV epinephrine	24 (1.1)	2 (1.6)	5 (0.7)	10 (1.4)	7 (1.3)	0.5
IV corticosteroid	178 (8.3)	7 (5.5)	33 (4.4)	57 (8.0)	81 (14.9)	<0.001
IV crystalloid	77 (3.6)	2 (2.4)	10 (1.3)	20 (2.8)	44 (8.1)	<0.001
Inhaled epinephrine	49 (2.3)	2 (1.6)	19 (2.5)	10 (1.4)	18 (3.3)	0.1
Inhaled salbutamol	308 (14.4)	9 (7.1)	104 (13.8)	126 (17.7)	69 (12.7)	0.004
Inhaled salbutamol and ipratropium bromide	81 (3.8)	5 (3.9)	19 (2.5)	38 (5.3)	19 (3.5)	0.042
Endotracheal intubation	2 (0.1)	0	0	1 (0.1)	1 (0.2)	0.7

Proportions exclude missing data. Abbreviations: IM = intramuscular; IV = intravenous; IQR = interquartile range.

for anaphylaxis presentations. The reasons behind the increase in EMS presentations are likely to be multifactorial. These include an increase in the burden of anaphylaxis in the community, development of *de novo* allergies, and an increase in the severity of reactions among patients with established disease (4). In addition, increasing public awareness of the importance of early recognition and treatment of anaphylaxis may also promote the early use of EMS compared with alternative methods of assessment (e.g., self-presentation to hospital). Our data therefore indicates that EMS are likely to play a significant role in the early management of pediatric anaphylaxis in the future.

A key strength of our study is the reporting of clinical observations on arrival of EMS. Our findings show that the vast majority of patients receiving epinephrine do not present with overwhelming evidence of respiratory or circulatory compromise. For instance, in patients receiving epinephrine after EMS arrival, only one-third presented with abnormal heart rate, while less than one-quarter exhibited abnormal blood pressure. As such, decisions to initiate intramuscular epinephrine appear to be based predominantly on the other physical manifestations of anaphylaxis, including angioedema, urticaria, dyspnea, and gastrointestinal complaints. A small report involving 178 EMS presentations of pediatric anaphylaxis in the United Kingdom reported that fewer than 3% were tachypneic, hypoxemic, or hypotensive (9). This may, in part, be due to difficulties in the assessment of the distressed child, where observations such as systolic blood pressure and pulse oximetry may be difficult to obtain in the early stages of care.

Importantly, our data shows that only a small proportion of patients require intensive EMS treatment beyond the use of intramuscular epinephrine. This is particularly true for cases treated with epinephrine before EMS arrival, of which only a small proportion (13%) required a further dose of epinephrine by

paramedics. Although inhaled salbutamol was infrequently administered in our population, interventions such as intravenous epinephrine, intravenous crystalloids, and endotracheal intubation were extremely rare. In addition, the low rate of out-of-hospital cardiac arrest in our population is consistent with earlier reports showing that fatal cases of anaphylaxis are rare in both hospital and pre-hospital settings with prompt EMS attendance (4,7–9).

While it is difficult to verify whether all cases receiving epinephrine before EMS arrival warranted this treatment, our data suggests that autoinjector use was associated with fewer abnormalities of vital signs on arrival of EMS. It is possible that a proportion of these cases represent localized allergic reactions, and this could explain the absence of signs of systemic involvement on EMS arrival. However, it could also indicate that patients who are treated with epinephrine before EMS arrival have earlier restoration of normal physiological values, and are therefore less likely to present with clinical signs of deterioration. This observation supports the view that epinephrine autoinjector use in these populations is safe and effective.

Limitations

Our work has several limitations. Although our study had a relatively small amount of missing data overall, observations such as the suspected allergen, initial blood pressure, and initial oxygen saturation were missing in some cases. However, it is not uncommon to develop anaphylaxis with no obvious reaction to an allergenic substance (9,18). In addition, it is also difficult to obtain accurate vital sign measurement in a distressed child in the prehospital setting, and this inherently contributes to the likelihood of an incomplete vital signs assessment, particularly in very young children. Also, we are not able to report hospital outcome data; however, deaths due to anaphylaxis after

hospital admission are seldom reported in medical literature. Similarly, we are unable to determine whether patients who were not administered epinephrine by EMS should have received it, or determine the appropriateness of treatment. Finally, it is difficult to determine from our data whether all cases receiving epinephrine before EMS arrival were due to anaphylaxis. It is possible that some of these cases involved milder allergic reactions that did not warrant the use of epinephrine.

CONCLUSION

In this study, the incidence of pediatric anaphylaxis-related EMS presentations increased significantly over an 8-year period, and this was accompanied by increases in cases requiring epinephrine administration both before and after EMS arrival. Although the frequency of these cases is increasing, our data suggests that most patients present hemodynamically stable after initial intramuscular epinephrine administration and few require additional emergency treatment such as intubation and/or intravenous epinephrine.

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Pediatric anaphylaxis in the prehospital setting: incidence, characteristics and management.

Supplementary Appendix

Table S1: Age-specific vital sign observations used in this study.

	<3 months	3-12 months	1-4 years	5-11 years	12-16 years
Pulse rate, beats per min					
Bradycardia	<110	<105	<85	<70	<60
Normal	110-190	105-165	85-150	70-135	60-120
Tachycardia	>190	>165	>150	>135	>120
Respiratory rate, breaths per min					
Bradypnea	<25	<25	<20	<16	<14
Normal	25-60	25-55	20-40	16-34	14-26
Tachypnea	>60	>55	>40	>34	>26
Systolic blood pressure, mmHg					
Normal	>60	>65	>70	>80	>95
Hypotensive	≤60	≤65	≤70	≤80	≤95

Figure S1: Patient selection flow-chart between 1 July 2008 and 30 June 2016.

