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Administration of Epinephrine for Life-Threatening Allergic Reactions in School Settings

C. Lynne McIntyre, RN, PhD*; Anne H. Sheetz, RN, MPH†; Constance R. Carroll, RN, MPH§; and Michael C. Young, MD||

ABSTRACT. *Objective.* Although the potential for life-threatening allergic reactions in children is a significant health concern for schools, there is little information about the circumstances surrounding anaphylactic events that occur in schools. The objectives of this study were to determine the incidence of anaphylaxis in schools, describe the circumstances around anaphylactic events, assess practices that are used to manage students with life-threatening allergies, and identify opportunities for improvement.

Methods. A total of 109 school districts in Massachusetts completed an Epinephrine Administration Form whenever epinephrine was administered at school. Data were collected from September 2001 to August 2003.

Results. Forty-eight school districts reported a total of 115 administrations of epinephrine during the 2-year reporting period. In 24% of the cases, the individual was not known to have a life-threatening allergy. Almost one third (31%) of the students who received epinephrine had allergies to multiple substances, and one quarter (25%) had an allergy to peanuts or tree nuts only. Twenty-two (19%) cases occurred outside the school building on the playground, traveling to and from school, or on field trips. The administration of epinephrine most often occurred in the health office by a registered nurse. The average time from onset of symptoms to administration of epinephrine was 10 minutes. In 92% of the cases, the student was transported to a medical facility via the emergency medical system.

Conclusions. Anaphylactic reactions in schools, although not frequent, are not uncommon events. A systematic review of anaphylactic events that required epinephrine administration identified opportunities for improvement in the treatment of students with life-threatening allergies. *Pediatrics* 2005;116:1134–1140; allergy, public health, school.

ABBREVIATIONS. MDPH, Massachusetts Department of Public Health; ESHS, Essential School Health Services; EMS, Emergency Medical System; LTA, life-threatening allergy.

The potential for life-threatening allergic reactions in children has emerged as a significant health issue for schools. It is estimated that 1% to 2% of the general population is at risk for anaphylaxis caused by food allergies or insect stings, with lower estimates for allergies to drugs and latex.¹ Among children, the most common causes of anaphylaxis are allergies to foods, stinging insects, and medications.² In recent years, there have also been reports of exercise-induced anaphylaxis.² The prevalence of food allergies has increased over the past several years,^{3–5} with current estimates of ~2 million school-aged children with food allergies.³ This has resulted in many more students with the potential for life-threatening allergic reactions in the school system, creating heightened concern about the ability of schools to ensure the safety of these students and respond appropriately to anaphylactic events.

Studies that have examined anaphylactic events in children have found that epinephrine is frequently not available or used,^{6–9} although timely administration of epinephrine has been identified as an important factor in preventing fatalities.^{10,11} In 1998, the American Academy of Allergy, Asthma and Immunology issued a position statement on the management of anaphylaxis in schools, recommending epinephrine as the first drug to be used in the treatment of children with life-threatening allergic reactions.¹ Despite this guidance, studies that focused on school preparedness identified several deficiencies in treating students with life-threatening allergies. Many schools did not provide their staff with education on how to prevent allergic reactions or respond to life-threatening events.^{12–15} Written student-specific emergency plans for staff to follow in the event of an allergic reaction were frequently not available or used,^{12–14} and, in some cases, there was no physician's order or supply of epinephrine available in schools for administration.^{12,14,16}

The School Health Unit at the Massachusetts Department of Public Health (MDPH) initiated a quality improvement project to monitor the administration of epinephrine in schools. The goal of this project was to (1) determine the frequency of epinephrine administration in schools, (2) examine the

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circumstances around anaphylactic events and the clinical features of the reactions, (3) assess current practices that address the issue of life-threatening allergies in school, and (4) identify opportunities for improvement from both a preventive and a treatment perspective. This article is a report of the findings to date.

METHODS

Participants

School nurse leaders in 109 Massachusetts school districts with an Essential School Health Services (ESHS) grant¹⁷ were asked to complete an Epinephrine Administration Form (Fig 1) for each student who received epinephrine in the school setting. Additional public school districts and nonpublic schools that received

School Health Unit Massachusetts Department of Public Health

Report of EpiPen® Administration

School District: _____ Date/Time of occurrence: _____

Age of student: _____ Gender: M ☐ F ☐ Known allergen(s): _____

Trigger that precipitated this allergic episode: _____

Symptoms: _____

Location of student when symptoms developed: _____

Location of student when EpiPen® administered: _____

Location of EpiPen® storage: _____

EpiPen® administered by: RN ☐ Other ☐ If other, please specify _____

If other than a RN, was this person formally trained? Yes ☐ No ☐ Date of training _____

If EpiPen® was self-administered by a student at school or a school-sponsored function, did the student follow school protocols to notify school personnel and activate EMS? Yes ☐ No ☐ NA ☐

Approximate time between onset of symptoms and administration of Epi Pen®: _____

Individual Health Care Plan (IHCP) in place? Yes ☐ No ☐

Written school district policy on management of life-threatening allergies in place? Yes ☐ No ☐

School building emergency response team activated Yes ☐ No ☐ NA ☐

Emergency Medical System:

Epinephrine available: Yes ☐ No ☐

Other emergency measures performed: _____

Disposition:

Outcome:

Recommendations for changes/improvements to current policy or procedures:

Form Completed By: _____ Date: _____

Title: _____ Phone number: _____

Address: _____

Fig 1. Data collection form for epinephrine administration.

consultation services from an ESHS program were also asked to participate. The total number of students enrolled in these school systems was 798 762: 721 191 public school students and 77 571 nonpublic school students. The school districts range in size from ~300 students to ~62 000 students and include rural, suburban, and urban settings from all regions within the state.

Procedures

The staff of the School Health Unit of the MDPH developed a data collection form that was reviewed by experts in the field for content validity. The form was presented to the nurse leaders of the 109 ESHS programs at a statewide meeting in the fall of 2001, along with an explanation of the project. Nurse leaders were asked to share the information with other school districts and nonpublic schools participating in the ESHS program.

Completed forms were forwarded to the School Health Unit for review and analysis. Reporting was done without personal identifiers, as indicated on the sample data collection form (Fig 1); therefore, Institutional Review Board approval was not required. Data were collected for 2 school years from September 2001 through August 2003. At regular intervals, the department gave feedback to the nurses on the results of the data analysis, as well as recommendations for improvement in practice.

Analysis

Data were analyzed using the statistical software package SPSS 10.0.¹⁸ Descriptive statistics were used to describe the characteristics of students and anaphylactic events in schools. One-way analysis of variance was used to examine associations among variables. The level of significance was set at .05.

RESULTS

Characteristics of the Sample

Forty-eight public school districts reported at least 1 administration of epinephrine during the data collection period. Of these, 22 school districts reported >1 administration (range: 2–24 administrations). Four epinephrine administrations were reported by nonpublic schools. Forty-eight administrations occurred during the 2001–2002 school year, and 67 administrations took place during the 2002–2003 school year. During the data collection period, epinephrine administrations were reported for each month of the school year, ranging in frequency from 7 administrations during the month of December to 18 administrations in the month of May. The majority of individuals with allergic reactions in this study were elementary-age students. In addition to students, epinephrine was administered to 4 adult staff members in the school systems. The characteristics of the students and adults in this study are provided in Table 1.

Characteristics of the Patients

The type of allergy reported by study participants is shown in Table 2. Twenty-five percent of the reac-

TABLE 2. Type of Allergy Reported by Study Participants (N = 114)

Type of Allergy	No. (%) of Study Participants
Peanut	21 (18)
Tree nuts	8 (7)
Shellfish	3 (3)
Stinging insects	11 (10)
Multiple allergens	41 (36)
Other	11 (10)
Exercised induced (3)	
Red dye (3)	
Latex (3)	
Other foods (apples, peas, mustard; 3)	
Cold sensitivity (1)	
Horsehair (1)	
Medication (2)	
Unknown	19 (17)

tions involved students who had allergies only to peanuts or tree nuts. More than one third (36%) of reactions occurred in study participants who had allergies to multiple substances. Among those who reported multiple allergies, the most common allergens listed were tree nuts (54%) and peanuts (51%).

In many cases (60%), the allergic reaction was reported to have resulted from some type of food exposure, such as “eating a cookie” or “eating lunch.” However, the specific allergen responsible for triggering the reaction could be identified in only 43% of the food-related allergic reactions. Approximately two thirds (66%) of the reactions involving students with multiple allergies were related to some type of exposure to food. Among students with food allergies, most reactions were caused by the ingestion of food, although there were a few instances in which inhalation or cutaneous contact with food was reported as the cause of the allergic reaction.

In 28 (24%) cases, school personnel were not aware that the individual had a life-threatening allergy and therefore had no individualized health care plan and no physician’s order for epinephrine administration specific for that individual. In at least 5 of these cases, the students had received a diagnosis of an allergic condition, but this information had not been communicated to the school nurse. The largest group of students with previously undiagnosed allergic conditions was in middle school. Of the 4 adults in this study who received epinephrine, 2 were unaware that they had a life-threatening allergy.

The onset of symptoms occurred most frequently in the classroom (Table 3). In 22 cases, symptoms developed outside the school building: on the playground, at home, traveling to and from school, or on

TABLE 1. Characteristics of Study Participants Who Received Epinephrine (N = 114)

Characteristics	%
Age category of all participants	
Prekindergarten	2
Elementary	46
Middle school	29
High school	19
Adult (age range: 43–59 y)	4
Gender	
Male	54
Female	46

TABLE 3. Location Where Allergic Reactions Occurred (N = 110)

Location	% of Cases
Classroom	46
Health office	17
Playground	10
Cafeteria	9
Home	2
Gym	3
Other	13

a field trip. Six of these allergic reactions were attribute to insect stings. Almost 75% of the students who experienced reactions outside the school building were elementary-age children.

The type of symptoms developed by the participants ranged from itching, swelling, and hives to severe hypotension with loss of consciousness. Almost two thirds of the cases had symptoms involving 2 or more organ systems. Seventy-five percent of the cases had symptoms involving the respiratory system, and 63% of the cases had symptoms involving the skin, such as hives or rashes.

The severity of anaphylactic reactions in the study participants was classified according to a grading system developed by Sampson.¹⁹ In this system, grade 1 anaphylaxis is characterized by milder symptoms, such as localized urticaria or oral pruritus, whereas grade 5 anaphylaxis includes the most serious symptoms, such as severe hypotension, loss of consciousness, and/or cardiorespiratory arrest.¹⁹ Certain symptoms, such as complaints of itchy or tight throat, wheezing, difficulty swallowing, "barky" cough, or dyspnea, were highlighted as symptoms that are "absolute indications for the use of epinephrine."¹⁹

On the basis of the grading system developed by Sampson,¹⁹ more than three fourths of the reactions in this study would be classified as grade 3 or higher, including 1 grade 5 reaction with hypotension (Fig 2). Seventy-four percent of the reactions included symptoms that were considered to be absolute indications for the administration of epinephrine. The grade 5 reaction involved an adolescent student who had peanut allergy and experienced symptoms that included urticaria, vomiting, hypotension, bradycardia, and loss of consciousness after eating candy with peanuts. Epinephrine was administered within 8

minutes of the onset of symptoms. The student was transported to a medical facility and was discharged later that day with no additional problems.

Characteristics of the Treatment Used to Manage Anaphylaxis in Schools

The administration of epinephrine most frequently occurred in the health office, although administrations also occurred in the classroom, cafeteria, the hallway, main office, and locations outside the school building (Table 4). In most cases, the epinephrine was stored in the health office, although some school districts stored epinephrine in the main office. Some students had EpiPens stored in 2 locations, such as the classroom and the health office or the cafeteria and the health room. At least 4 of the 9 students who carried their own EpiPen had a backup in the health office. A registered nurse administered the epinephrine in 91% of the cases. There were 6 instances in which the epinephrine was self-administered and 3 instances in which other personnel, including a teacher, a coach, and an emergency medical technician, administered the medication. All of the unlicensed personnel had received formal training in the administration of epinephrine within the previous year.

The average time from onset of symptoms to administration of epinephrine for all cases was 10 minutes, with a range of 0 to 75 minutes. For individuals with known allergic conditions, the average time from onset of symptoms to administration of epinephrine was 9 minutes (range: 0–37 minutes), and for those with previously undiagnosed allergic conditions, the average time from onset of symptoms to administration of epinephrine was 14 minutes (range: 0–75 minutes). There was no significant difference between the mean response time for cases

Fig 2. Number of reactions by type of allergy and grade of symptom severity. Grading system from Sampson.¹⁹

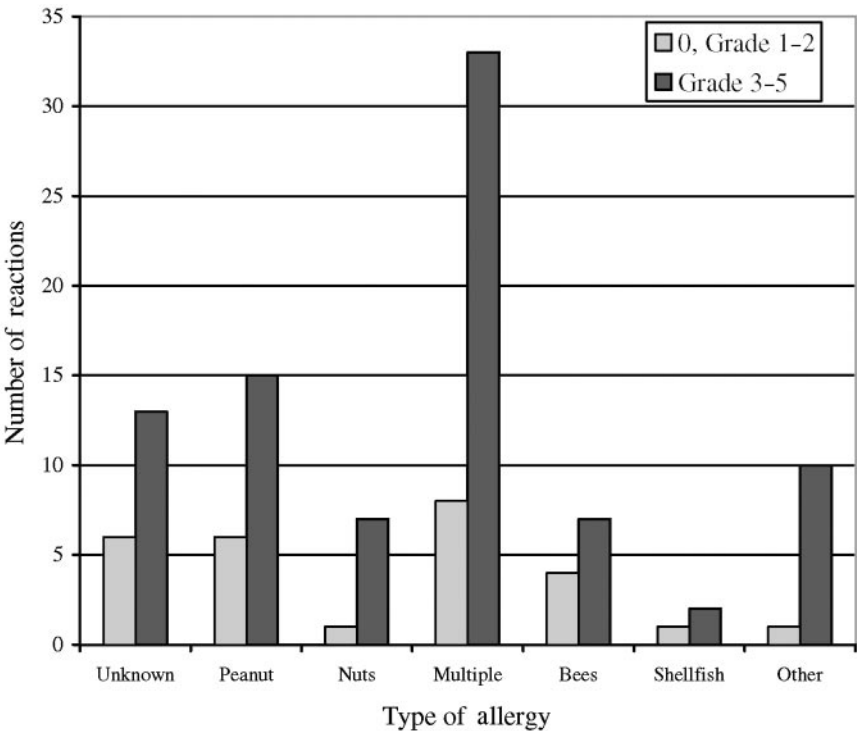


TABLE 4. Location of Epinephrine Administration (*N* = 114)

Location	% of Cases
Health office	91
Classroom	3
Cafeteria	2
Other	4

that occurred inside the school building (10.4 minutes; range: 0–75 minutes) and the mean response time for those that occurred outside the school building (10 minutes; range: 2–37 minutes). There was no significant difference in response time by grade of symptom severity ($F = .60$, $df = 105$, $P = .70$). There were only three cases in which the response time was >30 minutes.

Among students who were known to have an allergic condition, 92% had an individualized health care plan in place. In 91% of all the cases, a school policy that addressed the care of students with life-threatening allergies was in place, and in 62% of the cases, the emergency response system in the school was activated when it was determined that the student was exhibiting symptoms of anaphylaxis.

In the majority of the cases (92%), the individual who received epinephrine was transported to a medical facility via the Emergency Medical System (EMS) for additional observation and additional treatment if needed. All participants in this sample had positive outcomes in that they were treated and eventually returned home. At least 3 students were admitted to the hospital for additional observation after initial treatment in the emergency department. Another student had a recurrence of allergic symptoms the morning after his initial reaction and required emergency transportation from his home to a medical facility for additional treatment.

DISCUSSION

Practice Implications

Several important issues arose as a result of the study. First, a significant number of allergic reactions (24%) occurred in individuals who had no history of allergies. This finding supports previous research that reported that 25% of the children with peanut allergies experienced their first reaction in school.¹³ All of the individuals in this study received appropriate and timely treatment for anaphylaxis, but this finding illustrates the need for schools to have a protocol signed by the school physician that authorizes nurses to administer epinephrine to any individual who exhibits symptoms of anaphylaxis. In addition to the protocol, schools should have a supply of epinephrine on hand for such emergencies. The MDPH has recommended that all schools have a protocol for the administration of epinephrine signed by the school physician, as well as backup supplies of EpiPens.

Massachusetts law does not permit unlicensed personnel to administer epinephrine to individuals who have not previously received a diagnosis of a life-threatening allergy (LTA). In such cases, the EMS must be activated immediately to respond when a nurse or other licensed personnel is not present in

the building. This arrangement may result in a delay that could adversely affect the outcome. In this study, there was 1 instance of a student who had a previously undiagnosed LTA and developed symptoms of an allergic reaction when the school nurse was covering another school building. The nurse was able to respond, and the student was treated appropriately, but this case illustrates the need to have a definitive protocol in place for ensuring that school personnel are trained to recognize the symptoms of anaphylaxis and to respond appropriately by activating the EMS when a nurse is not available.

A second major issue identified was the need to transport all individuals to an emergency department for observation after the administration of epinephrine. In this study, 9 (8%) individuals were not transported to an emergency department. In every case, the decision not to transport was made by a parent, the student's primary care provider, or EMS. It has been estimated that as many as one third of the children who have a more severe manifestation of anaphylaxis (ie, grade 4 or 5) will have a biphasic reaction.¹⁹ These children typically have a period of being asymptomatic for several hours after the initial reaction before redeveloping symptoms. Symptoms in the late-phase reaction often do not respond to epinephrine and require more extensive treatment that is available only in an acute care facility. Fatalities as a result of the late-phase reaction have been reported in individuals who have been discharged prematurely from the emergency department.¹⁹ School policies should state clearly the need to transport immediately to a medical facility any student who receives emergency epinephrine, as recommended by the American Academy of Allergy, Asthma and Immunology.¹ In addition, school personnel, as well as parents, need education regarding the potential for biphasic reactions and the requirement for immediate follow-up care in a medical facility. The School Health Unit has disseminated information regarding this recommendation to school personnel through educational trainings and newsletters.

Another issue highlighted by this study was the need to plan for an emergency response to anaphylaxis when the student is outside the school building. Nineteen percent of the allergic reactions occurred on the playground, while the student was traveling to or from school, or on a field trip. This finding has several implications for practice. First, mechanisms should be in place to ensure the safety of children who are at risk for life-threatening allergies on the playground. This would include training playground monitors in the recognition and appropriate response to allergic reactions, the establishment of a communication system that enables playground monitors to communicate with personnel inside the building, and, in some cases, having EpiPens available on the playground for students who have a history of severe allergic reactions.

In addition, protocols need to be developed for ensuring the safety of children who are traveling to and from school. Bus drivers need to be trained in the recognition and management of life-threatening

allergic reactions. They also need to have a means of communicating with emergency personnel and an awareness of the local EMS procedures. Careful planning needs to occur before field trips, ensuring that chaperones are trained properly to recognize and respond appropriately to life-threatening allergic reactions, that appropriate precautions are taken to prevent accidental exposure to the offending allergens, and that EpiPens for students with previously diagnosed allergies are readily available. Again, there needs to be an established mechanism for contacting EMS in the event of an allergic reaction.

This study confirmed the potential for food-related allergic reactions at times other than the lunch period. Allergic reactions to foods also occurred during parties or special events (8), as the result of a bake sale (1), and during culinary classes (4). Five reactions involving foods were the result of tactile contact or inhalation rather than ingestion. Three of these cases involved students with an allergy to shellfish: 1 student touched his face with a gloved hand that was contaminated with shellfish juice, another student was sprayed with shellfish juice during culinary class, and a third student had contact with water from a fish tank. A student with a peanut allergy had an allergic reaction to a class project that included peanut butter, and another student was reported to have developed hives and swelling of the left side of the face and eye from the scent of peanut butter in the cafeteria.

That the actual trigger that precipitated many food-related allergic reactions was not identified is especially challenging. In some cases, the individual may have developed an allergy to a new substance. On other occasions, the reaction could have been triggered by contact with a known allergen through cross-contamination or exposure to a food that contained the offending allergen as a hidden ingredient. A thorough investigation of such events is essential to the prevention of additional reactions.

One adult and 6 students, ranging in age from 11 to 17 years, self-administered their epinephrine. In all cases, school personnel were notified and the appropriate actions were taken to transport the student to a medical facility. There were at least 2 instances in which adolescent students who were authorized to carry their own epinephrine did not have an EpiPen available when they needed it. This points out the need for safeguards and a system of periodic checks for the availability of the EpiPen. There were also a few cases in which the parents of students with known life-threatening allergies did not provide the school with an EpiPen, although the child had been prescribed epinephrine. In these situations, it is imperative that there be a stock supply of epinephrine available in the school building at all times.

Policy Implications

This study provides guidance in both policy development and ongoing education of staff. Because the reports on EpiPen usage have proved to be such a rich data source with many implications for quality improvement, the MDPH amended its medication

regulations in November 2003 to include a mandatory reporting requirement for all schools in the Commonwealth of Massachusetts whenever an EpiPen is administered.²⁰ Department staff have initiated follow-up letters to the schools acknowledging their rapid response and/or identifying areas for improvement, as needed.

Although few of the allergic events occurred during attendance at before- and after-school programs, the potential for this to happen certainly exists. Therefore, the amended regulations provide an option for schools to teach unlicensed personnel to administer EpiPens in before- and after-school programs to students with a diagnosed allergy, as defined by the school. The regulations also permit schools to provide this service for students who are from other schools and attend these programs, provided that certain conditions are met.²⁰

Limitations

An important limitation of this study is the voluntary reporting of epinephrine administration. Although the mandatory reporting requirement will increase the likelihood that epinephrine administration is reported, there is currently no mechanism in place to determine the percentage of actual administrations that are reported to the MDPH. Variations in reporting among regions in the state have been noted, but it is not possible to determine whether these differences are attributable to reporting practices or actual differences in epinephrine administration.

By design, there are no unique identifiers for subjects on the data collection form. Therefore, it is not possible to use this information to describe the characteristics of students who experience life-threatening allergies in schools, as there is no assurance that the allergic events are not occurring repeatedly in the same student. Consequently, although information from this study is useful for examining practices associated with caring for students with LTAs in schools, it is not possible to use the data for surveillance purposes. In an effort to address this issue, the data collection form is currently undergoing revision to capture information on student race/ethnicity and history of asthma and of allergic reactions that required epinephrine administration.

CONCLUSIONS

This study illustrates the complexity of providing safe care for students with life-threatening allergies in schools. By systematically collecting data on the diagnosis and treatment of allergic reactions in the school setting, vital information on both preventive measures and emergency response procedures was acquired. This information was essential in identifying opportunities for improving care through education and policy changes. Ongoing collection of data through a mandatory reporting requirement will provide a rich data source for issues related to EpiPen administration and furnish important information on the epidemiology of anaphylactic reactions in the school setting.

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MANY WOMEN AT ELITE COLLEGES SET CAREER PATH TO MOTHERHOOD

“At Yale and other top colleges, women are being groomed to take their place in an ever more diverse professional elite. It is almost taken for granted that, just as they make up half the students at these institutions, they will move into leadership roles, on an equal basis with their male classmates. There is just one problem with this scenario: many of these women say they have already decided that they will put aside their careers in favor of raising children. Though some of these students are not planning to have children and some hope to have a family and work full time, many others . . . say they will happily play a traditional female role, with motherhood their main commitment. . . . ‘At the height of the women’s movement and shortly thereafter, women were much more firm in their expectation that they could somehow combine full-time work with child rearing,’ said Cynthia E. Russett, a professor of American history who has taught at Yale since 1967. ‘The women today are, in effect, turning realistic.’”

Story L. *New York Times.* September 20, 2005

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