

Improving Anaphylaxis Care: The Impact of a Clinical Pathway

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BACKGROUND: Recommended durations of observation after anaphylaxis have been widely variable, with many ranging from 4 to 24 hours. Prolonged durations often prompt admission for ongoing observation.

METHODS: In a multidisciplinary quality improvement initiative, we revised our emergency department (ED) anaphylaxis clinical pathway. Our primary aim was to safely decrease the recommended length of observation from 8 to 4 hours and thereby decrease unnecessary hospitalizations. Secondary aims included provider education on anaphylaxis diagnostic criteria, emphasizing epinephrine as first-line therapy, and implementing a practice of discharging ED patients with an epinephrine autoinjector in hand. The study period consisted of the 18 months before pathway revision (baseline) and the 18 months after revision.

RESULTS: The overall admission rate decreased from 58.2% (106 of 182) in the baseline period to 25.3% (65 of 257) after pathway revision ($P < .0001$). There was no significant difference in the percentage of patients returning to the ED within 72 hours, and there were no adverse outcomes or deaths throughout the study period. After pathway revision, the median time to first epinephrine administration for the most critical patients was 10 minutes, and 85.4% (164 of 192) of patients were discharged with an epinephrine autoinjector in hand.

CONCLUSIONS: By revising an anaphylaxis clinical pathway, we were able to streamline the care of patients with anaphylaxis presenting to a busy pediatric ED, without any compromise in safety. Most notably, decreasing the recommended length of observation from 8 to 4 hours resulted in a near 60% reduction in the average rate of admission.

Anaphylaxis is a severe, multisystem reaction that can be life-threatening. The most common triggers of anaphylaxis in pediatrics are food allergies, which affect 4% to 8% of children in the United States and carry a high economic burden of \$25 billion per year.¹⁻⁴

Successful management of anaphylaxis requires prompt recognition of the diagnosis and treatment with epinephrine. Epinephrine is the only first-line treatment, and

delayed administration has been associated with fatal anaphylaxis.⁵⁻¹²

Antihistamines and corticosteroids, although often administered, should be considered adjunctive therapies.

The emergency department (ED) plays a vital role in the management of anaphylaxis. A patient presents to the ED with a food allergy reaction every 3 minutes, meeting anaphylaxis criteria every 6 minutes, altogether resulting in 200 000 ED visits annually.¹³ Furthermore, ED visits for anaphylaxis

abstract

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Dr Lee conceptualized and designed the study, conducted data analysis and interpretation, and drafted the initial manuscript; Ms Rodio acquired data, supervised improvement interventions, and reviewed and revised the manuscript; Drs Lavelle, Tsarouhas, and Brown-Whitehorn supervised all aspects of the study, including conceptualization and design of the study, interpreted data, and reviewed and revised the manuscript; Ms Lewis and Ms Molnar conceptualized and designed the study, conducted data analysis, and reviewed and revised the manuscript; Ms English and Ms Hadley coordinated and developed tools for data collection and reviewed and revised the manuscript; Ms Zielinski helped conceptualize the study, conduct improvement interventions, and reviewed and revised the manuscript; Drs Jacobstein, Cianferoni, and Spergel helped analyze and interpret data and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

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have increased significantly over the past decade, particularly in the pediatric population.^{14,15} Since the first description of biphasic anaphylaxis, the recurrence of symptoms after a period of resolution without re-exposure to the trigger, observation periods ranging from 3 to 4 hours to a minimum of 24 hours have been recommended.^{16–24} This wide range can lead to variation in clinical decision-making, more hospitalizations or prolonged ED stays, increased costs, inconsistent discharge care, and caregiver confusion. Fortunately, biphasic anaphylaxis appears to be uncommon, with the authors of most pediatric studies reporting rates of ~10% or less.^{18,22–24} In the current anaphylaxis practice parameters, 4 to 8 hours of observation is recommended.^{6,25}

At our institution, a multidisciplinary team of content experts and front-line clinicians reviewed available evidence and generated expert consensus to create a clinical pathway guiding the ED management of anaphylaxis in 2011. The pathway was used to implement education, clinical decision support that included a templated electronic medical record note, and an electronic order set. In the initial version, 8 hours of observation was recommended, and as a result, the majority of anaphylaxis patients were admitted to the ED observation unit or an inpatient unit. In 2014, a discrepancy in anaphylaxis management was noted; in accordance with consensus guidelines, patients with oral food challenges are discharged 2.5 hours after epinephrine administration, provided that symptoms have resolved.²⁶ Nationally, an observation period of 4 to 6 hours is discussed for most anaphylaxis patients.⁹

Thus, the multidisciplinary team reconvened in 2014 to revise the ED anaphylaxis clinical pathway and launch a quality improvement

project to measure the impact of the revision. The team aimed to safely reduce the ED length of observation and decrease unnecessary hospitalizations. Secondary aims included provider education on anaphylaxis diagnostic criteria, emphasizing epinephrine as the first-line and most important therapy, and implementing a practice of discharging patients with an epinephrine autoinjector in hand.

METHODS

Setting

The Children's Hospital of Philadelphia (CHOP) is an urban, tertiary, university-affiliated 527-bed children's teaching hospital with over 90 000 ED visits per year. The ED is staffed by board certified and/or eligible Pediatric Emergency Medicine attending physicians and pediatricians, fellows, residents, nurse practitioners, physician assistants, registered nurses (RNs), and technicians. Patients are triaged by experienced RNs using the Emergency Severity Index (ESI), with ESI level 1 indicating the highest acuity. Approximately 7% of all patients seen within the CHOP network have at least 1 documented food allergy.²⁷

Design

Our multidisciplinary team consisted of physicians, nurse practitioners, and RNs from the divisions of Pediatric Emergency Medicine and Allergy, as well as including an improvement adviser and data analyst from the Office of Clinical Quality Improvement. We held biweekly meetings for several months to review literature and discuss revisions to the existing pathway. We reviewed our evidence summary with all clinicians in both disciplines for further input before releasing the updated pathway. In accordance with institutional review board standards at our institution,

this study was exempt from institutional review board oversight, because no subjects were randomly assigned and no experimental data were collected.

The Intervention

The Division of Allergy had previously established that the 2.5-hour observation period for oral food challenges was safe, with biphasic reactions occurring rarely.²⁴ We did recognize, however, that patients undergoing food challenges are not entirely comparable with patients presenting to an ED with anaphylaxis. Food challenge patients are prescreened so that ~50% will not react and are monitored closely during the challenge so that anaphylaxis can be treated expeditiously, should it occur.²⁶ To acknowledge this difference, and to stay within the range of observation length recommended by current anaphylaxis guidelines, we chose to decrease the observation length from 8 to 4 hours, rather than to 2.5 hours.

In the revised pathway, discharge was recommended after 4 hours of observation subsequent to the initial epinephrine administration, as long as the following criteria were met: (1) a complete resolution of anaphylaxis symptoms (sporadic hives were considered acceptable for discharge), (2) the absence of any severe symptoms or anaphylaxis "red flags," and (3) parental comfort with access to an ED in case symptoms recurred. We compiled a list of anaphylaxis red flags on the basis of literature on biphasic anaphylaxis and recommended that patients be admitted if any red flag was present^{16–24,28}: (1) history of biphasic or severe reactions, (2) progression of or persistent symptoms, (3) history of severe asthma, (4) current asthma flare, (5) hypotension during ED stay, (6) requires >1 epinephrine dose, or (7) requires fluid bolus.

To emphasize epinephrine as the first-line therapy, we placed a chart

outlining the diagnostic criteria previously established by expert consensus on the main pathway screen.⁵ We anticipated that this would help trigger quick recognition of anaphylaxis and facilitate prompt treatment. Additionally, we highlighted on the pathway screen that the first-line treatment of anaphylaxis is epinephrine, delivered intramuscularly.

We also implemented a new practice of discharging patients from the ED with an epinephrine autoinjector in hand (Fig 1). The nurse reviews signs and symptoms for which to use the autoinjector, along with indications for returning to the ED. Patient handouts guiding avoidance of specific food allergens, along with information on how to obtain Medical Alert bracelets or necklaces, are available. Instructions are reviewed verbally and supplemented with written instructions. Patients are referred to CHOP Allergy for follow-up.

The revised pathway went “live” on October 20, 2014 (<http://www.chop.edu/clinical-pathway/anaphylaxis-emergent-care-clinical-pathway>). A hospital-wide announcement was made on the intranet and by internal e-mail to alert providers to this update.

Study of the Intervention

Our team met weekly for 2 consecutive months after the implementation of the revised pathway in October 2014. We reviewed new anaphylaxis cases and discussed feedback from ED bedside providers. Since then, we have held monthly meetings to review cases and trends. To investigate whether our measured outcomes were due to the pathway revisions, we chose to study and compare the cohort population seen in the ED during the 18 months before the revised pathway (baseline) with the population seen in the 18 months after the revision.

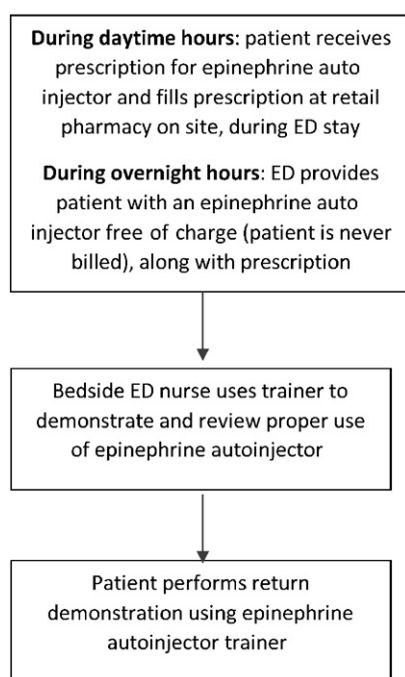


FIGURE 1
Process of discharging patients with epinephrine autoinjector in hand.

Measures

We used our hospital’s data warehouse to extract both retrospective and ongoing data on ED visits meeting our anaphylaxis cohort definition. We defined the cohort population as patients seen in the ED with a diagnosis of anaphylaxis by using *International Classification of Diseases, Ninth Revision* and *International Classification of Diseases, 10th Revision* codes (Table 1). We presumed that few cases of anaphylaxis would be missed using this method, because clinical decision support is offered through the pathway, including a list of suggested diagnosis codes. Important data fields extracted included ESI category; ED disposition; time to order and administration of medications given, including time to first epinephrine administration; and revisits to the ED within 72 hours. We pulled data on any encounters with a CHOP primary care site, urgent care center, or Allergy clinic within 72 hours of the initial ED visit. We reviewed nursing documentation to determine

TABLE 1 ICD Codes Used to Identify Anaphylaxis Patients

ICD-9 Codes	ICD-10 Codes
995.0	T78.2XXA
995.6X	T78.00XA
999.4	T78.01XA
999.41	T78.02XA
999.42	T78.03XA
999.49	T78.04XA
—	T78.05XA
—	T78.06XA
—	T78.07XA
—	T78.08XA
—	T78.09XA
—	T80.52XA

ICD, *International Classification of Diseases*; ICD-9, *International Classification of Diseases, Ninth Revision*; ICD-10, *International Classification of Diseases, 10th Revision*; —, not applicable.

if patients were discharged with an epinephrine autoinjector in hand. QlikView (Qlik, Radnor, PA) was used for data visualization, allowing us to track our progress over time.

The primary outcome measure was defined as the percentage of patients admitted from the ED to either the ED observation unit or an inpatient unit. The balancing measure was the percentage of discharged patients returning to the ED within 72 hours for symptoms related to the initial visit. Secondary outcome measures included time to first epinephrine administration for critical (ESI level 1) patients and the percentage of patients discharged with an epinephrine autoinjector in hand. We tracked the median time from ED arrival to administration of the first epinephrine, setting a target goal of ≤ 20 minutes. Although immediate administration of epinephrine is the goal, we felt that 20 minutes would account for all the elements that composed our measure of time to epinephrine: time from ED arrival to placement in the examination room, time from rooming to electronic order after patient assessment, and time from order to administration. Our target goal for the percentage of discharged patients leaving with an epinephrine autoinjector was $\geq 80\%$. We tracked the percentage

of patients with a referral order for CHOP Allergy follow-up and the percentage of patients who were seen in the Allergy clinic within 1 and 3 months of the ED encounter.

Analysis

For our primary outcome and balancing measures, we compared the cohorts seen during the 18-month baseline period to the 18 months after pathway revision. Proportions were compared by using Fisher's exact test. We also used Fisher's exact test for our measures related to Allergy referral and clinic follow-up. We used the Mann-Whitney *U* test to compare the median time to first epinephrine administration for critical (ESI level 1) patients before and after pathway revision. $P \leq .05$ was considered statistically significant for all analyses. Additionally, we used a run chart to monitor shifts in admission rate over time as pathway revisions were implemented. We calculated the centerline as the median of the monthly percentage of patients admitted during the prerevision period and extended this line into the future to allow for detection of signals of improvement by using run chart rules.²⁹

RESULTS

Admissions and Return Visits

There were 182 total cases of anaphylaxis seen in the ED during the 18-month baseline period before the pathway revision and 257 cases during the 18 months after the revision. In the baseline cohort, 58.2% of patients (106 of 182) were admitted. After the pathway revision, the overall admission rate was 25.3% (65 of 257), a reduction of 60% from baseline ($P < .0001$) (Table 2). The decrease in admissions occurred quickly after the revised pathway was released (as depicted by the run of over 6 consecutive points, all below the centerline in

TABLE 2 Comparison of Admissions and Revisits for Anaphylaxis Patients Before and After Pathway Revision

	Before Revision: April 20, 2013–October 19, 2014	After Revision: October 20, 2014–April 20, 2016	<i>P</i>
ED anaphylaxis patients	182	257	—
Median age, y	6.5	6	.60
Admitted (%)	106 (58.2%)	65 (25.3%)	< .0001
Discharges revisiting ED (%)	1 (1.3%)	5 (2.6%)	.99

—, not applicable.

Fig 2, signaling a shift), and this continues to be sustained beyond the 18-month study period. There was no statistically significant difference in the rate of patients returning to the ED within 72 hours for symptoms related to the initial visit: 1.3% (1 of 76) at baseline versus 2.6% (5 of 192) after pathway revision ($P = .99$). No patients in either cohort had an encounter at a CHOP primary site, urgent care center, or Allergy clinic for recurrence of symptoms within 72 hours of the initial ED visit. There were no deaths throughout the entire study period. Of the 5 patients who returned to the ED during the 18 months after the pathway revision, 4 patients returned with hives alone and 1 patient returned with increased work of breathing and wheezing. Of the 4 patients who returned with hives, 1 had self-administered epinephrine at home and the remainder were treated with oral antihistamines and/or corticosteroids in the ED. The patient who returned with respiratory issues was treated with epinephrine in the ED and ultimately admitted for treatment of an asthma exacerbation. None of these patients required ICU admission. The time from first ED presentation to subsequent ED presentation ranged from 13.5 to 36.5 hours, all outside the initial pathway observation period of 8 hours.

Time to Epinephrine

During the 18 months after pathway revision, the median time to first epinephrine administration in the ED for ESI level 1 patients was consistently less than our target goal

of ≤ 20 minutes (Fig 3). The overall median time to first epinephrine for this group was 10 minutes. During the 18-month baseline period, the overall median time was 15 minutes ($P = .87$).

Discharges With Epinephrine Autoinjector in Hand

Over the 18 months after the pathway revision, 85.4% of patients being discharged from the ED (164 of 192) had an epinephrine autoinjector in hand. For cases in which patients were not discharged with an epinephrine autoinjector, our ED nurse elicited feedback from ED providers. The main reason reported was that the patient already had an epinephrine autoinjector at home.

Allergy Referrals and Follow-up

Similar percentages of patients had an electronic referral order to CHOP Allergy before (62.1%; 113 of 182) and after (64.6%; 166 of 257) pathway revision (Table 3). Despite this, a higher percentage of patients were seen for follow-up in the Allergy clinic after pathway revision within 1 and 3 months of the ED visit (Table 3). It is possible that some portion of patients referred to Allergy went to an allergist outside our institution, because there are many other allergy practices in our area.

DISCUSSION

After implementing our revised ED anaphylaxis clinical pathway, incorporating a decreased recommended observation length from 8 to 4 hours, we successfully reduced the overall admission

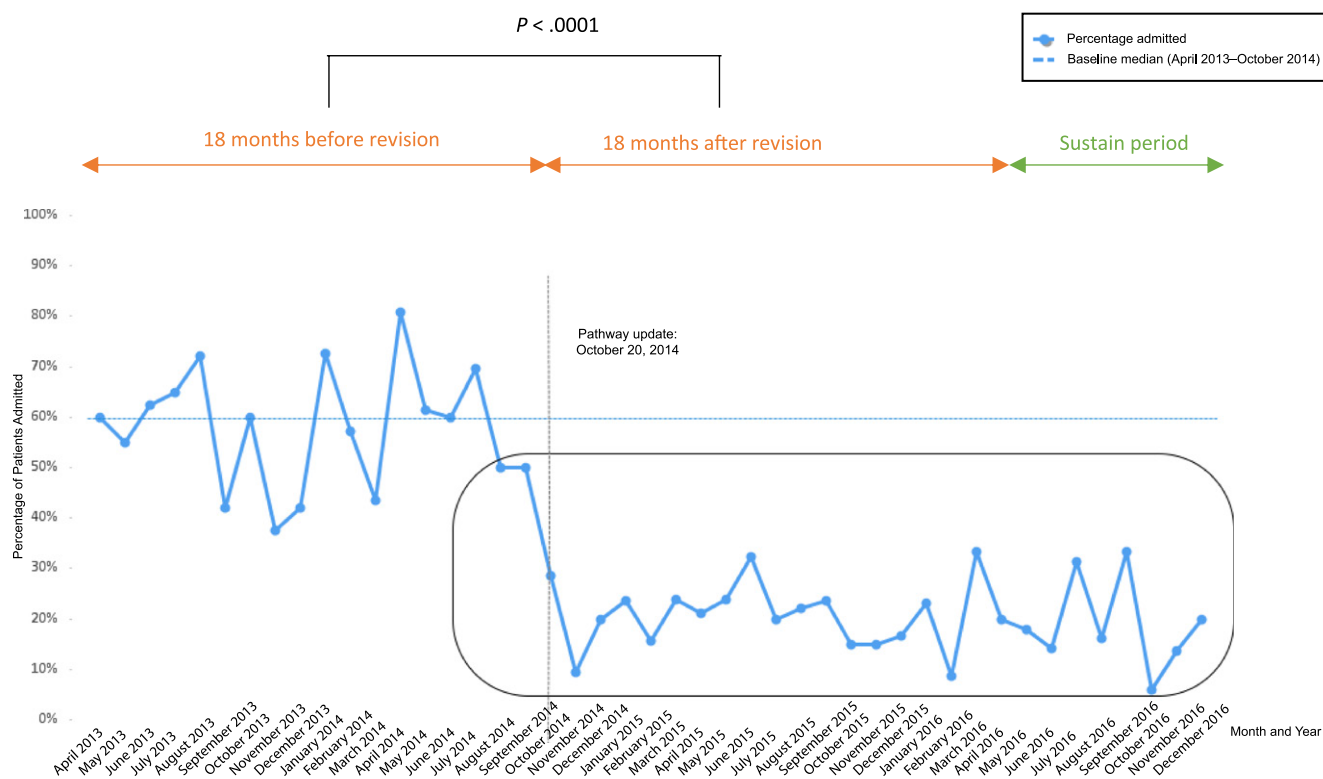


FIGURE 2
Run chart tracking admission rate.

rate by nearly 60%. This appears to be a safe practice, because the percentage of patients returning to the ED remained similar before and after the revision. The authors of previous studies have demonstrated that biphasic anaphylaxis in children is uncommon, and with our results, we support the authors of literature showing that prolonged observation periods are not generally necessary after anaphylaxis.^{17,30,31} The authors of a recent publication described the infrequency of inpatient interventions during pediatric hospitalizations for food-induced anaphylaxis, further supporting the safety of discharging most anaphylaxis patients and highlighting the importance of ongoing efforts to determine which patients truly require hospitalization.³²

Although we did not directly measure patient satisfaction or perform cost analysis, we believe that the reduced length of observation likely had a positive impact on patients and

their families. Hospitalization can have significant social implications, including missed time at school and work. Furthermore, the financial burden on patients can be substantially greater if they are hospitalized. Patel et al³³ evaluated the cost burden of food-induced anaphylaxis in the United States and found that, on average, an ED visit costs \$553 per patient whereas an inpatient admission costs \$4719, with an annual cost of \$4.8 million for ED visits and \$26.6 million for hospitalizations. Morbidity costs, including lost wages and absenteeism, accounted for 85% of indirect costs.

The mainstay of anaphylaxis management is the prompt administration of intramuscular epinephrine, because delayed administration has been associated with both biphasic and fatal anaphylaxis.^{5–12,17–21} This tenant of anaphylaxis therapy is reiterated in numerous multidisciplinary expert

panels and consensus guidelines from specialists in allergy and immunology, emergency medicine, pediatrics, and other fields.^{5,6,8–12} For this reason, an important secondary goal of this project was encouraging our ED staff to expeditiously recognize anaphylaxis and initiate therapy. The median time to first epinephrine during the 18-month period after the pathway revision for ESI level 1 patients was consistently less than our goal of ≤ 20 minutes, with an overall median of 10 minutes. After noting this trend, we have since lowered our target goal from 20 to 10 minutes and will be continuing to track sustainability. Although there was no statistically significant difference from the overall median time of 15 minutes in the baseline period, this is still a clinically significant improvement.

To promote successful achievement of this metric, ED clinicians participated in several joint educational sessions to review the

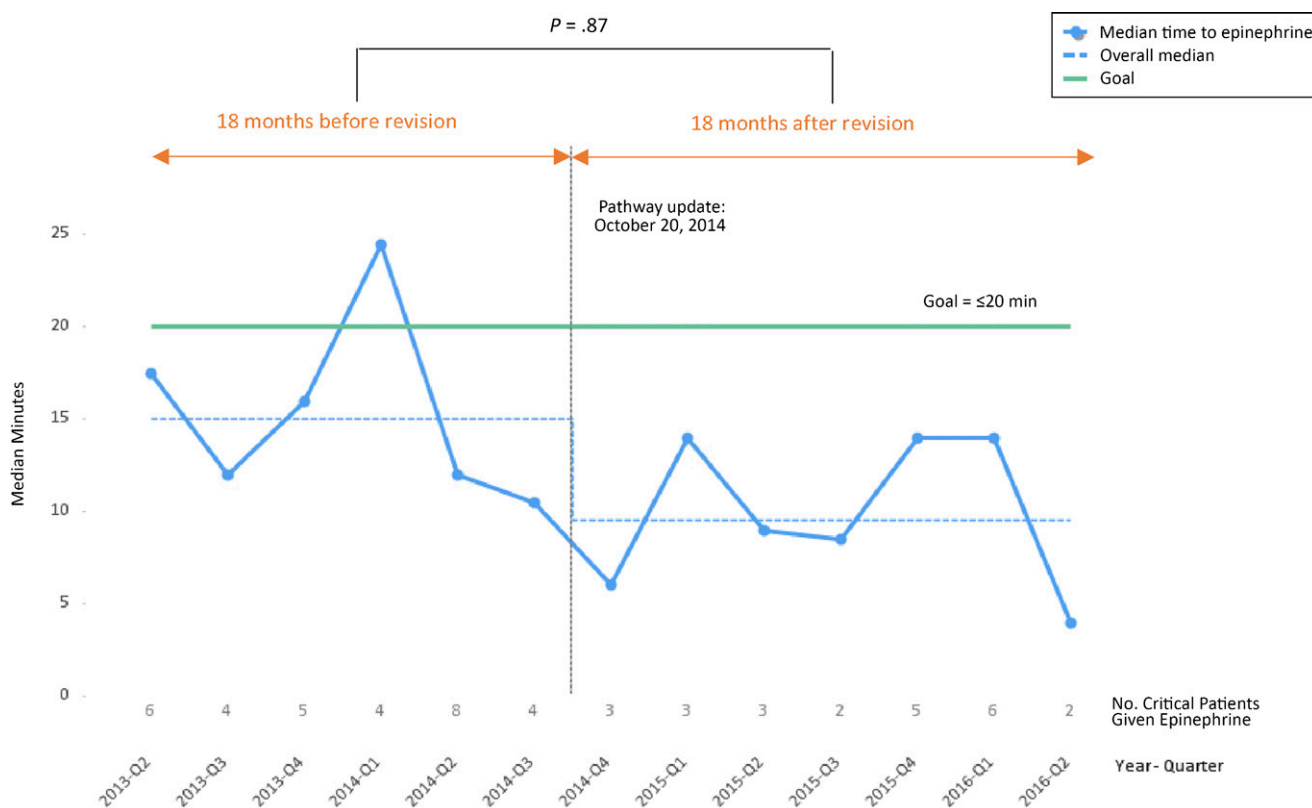


FIGURE 3 Run chart tracking median time to first epinephrine administration in ED. Q, quarter.

TABLE 3 Comparison of Allergy Referrals and Clinic Visits for Anaphylaxis Patients Before and After Pathway Revision

	Before Revision: April 20, 2013–October 19, 2014	After Revision: October 20, 2014–April 20, 2016	P
ED anaphylaxis patients	182	257	—
Allergy referral order	113 (62.1%)	166 (64.6%)	.62
Allergy clinic visit within 1 mo	37 (20.3%)	80 (31.1%)	.01
Allergy clinic visit within 3 mo	55 (30.2%)	103 (40.1%)	.03

—, not applicable.

pathway and diagnostic criteria for anaphylaxis. Triage protocols were reviewed with nursing staff. Team assessment (physicians and nurses jointly evaluating patients brought back immediately from triage) was stressed for anaphylaxis patients. Front-line ordering clinicians, as well as fellows and attending physicians, were encouraged to immediately order epinephrine by using the anaphylaxis order set, so that the nursing staff could expeditiously retrieve and administer the medication. Data about our progress were shared at our multidisciplinary

division meetings, included in the weekly RN updates, and posted on the ED Quality Board and on ED screensavers. These educational initiatives allowed for improvement in both prompt and accurate recognition of anaphylaxis, as well as timely administration of epinephrine. It is possible that this increased familiarity with anaphylaxis among providers also promoted improved education and guidance provided to families, because we saw a significant increase in the percentage of patients with Allergy follow-up after the pathway revision.

In consensus guidelines, it is also strongly recommended that patients discharged with the diagnosis of anaphylaxis leave the hospital with either a prescription for an epinephrine autoinjector or the autoinjector itself.^{5,6,8–12} Despite these recommendations, the authors of studies have shown that a large percentage of anaphylaxis patients do not receive a prescription at ED discharge, and of those who do receive an epinephrine autoinjector prescription, only ~60% fill it within a few days of receiving it.^{34–37} To ensure optimal safety for our patients, we implemented a process by which patients would be discharged from the ED with an actual epinephrine autoinjector in hand and set a goal to achieve this for ≥80% of discharged patients. We attained this goal, with 85% of discharged patients leaving with an epinephrine autoinjector during the 18 months after the pathway

revision. To our knowledge, this is the first successful implementation of such a process. We continue to work to sustain our successes, as well as to push to the ideal of 100% of anaphylaxis patients leaving with an epinephrine autoinjector.

This study has several limitations. Our project was limited to a pediatric population at a large, urban, tertiary-care center. Additionally, for our balancing measure of revisits to the ED, we only had information on returns to our own ED and may have potentially missed revisits to an outside hospital ED. However, this is unlikely to have been a frequent occurrence, and it would have been applicable for both

the periods before and after pathway revision.

CONCLUSIONS

By updating an anaphylaxis clinical pathway, we successfully and safely improved the care of patients presenting to a busy pediatric ED with anaphylaxis. Most notably, decreasing the recommended length of observation from 8 to 4 hours for anaphylaxis patients without severe symptoms or risk factors for biphasic anaphylaxis resulted in a near 60% reduction in the average rate of admission. A similar pathway could be used at other organizations to promote

the efficient care of anaphylaxis patients and help prevent unnecessary hospitalizations. In the next phase of our quality improvement project, we will continue to track sustainability, with new goals of ESI level 1 patients receiving epinephrine within 10 minutes of ED arrival and at least 90% of discharged patients leaving with an epinephrine autoinjector in hand.

ABBREVIATIONS

CHOP: Children's Hospital of Philadelphia
ED: emergency department
ESI: Emergency Severity Index
RN: registered nurse

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