

# Temporal Trends in Epinephrine Dispensing and Allergy/Immunology Follow-up Among Emergency Department Anaphylaxis Patients in the United States, 2005-2014



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**What is already known about this topic?** Previous studies suggest poor rates of concordance with emergency department (ED) post-discharge anaphylaxis care guidelines as demonstrated by low rates of epinephrine autoinjector (EAI) prescriptions and allergy/immunology (A/I) referrals.

**What does this article add to our knowledge?** Based on administrative claims data, 46% of patients filled an EAI prescription and 29% had A/I follow-up within 1 year of an ED anaphylaxis visit. Overall rates remained suboptimal with a minimal change from 2005 to 2014.

**How does this study impact current management guidelines?** Low rates of EAI dispensing and A/I follow-up suggest that additional patient and physician education is needed. Guidelines could be improved by specifically addressing if EAI prescribing is necessary for patients with a medication trigger.

**BACKGROUND:** Anaphylaxis is a potentially life-threatening allergic reaction; measures including prescription of an epinephrine autoinjector (EAI) and allergy/immunology (A/I) follow-up may prevent future morbidity.

**OBJECTIVE:** The objective of this study was to evaluate trends in outpatient management of anaphylaxis by studying EAI

dispensing and A/I follow-up among patients seen in the emergency department (ED) for anaphylaxis from 2005 through 2014. **METHODS:** We analyzed administrative claims data from the OptumLabs Data Warehouse database using an expanded International Classification of Diseases, Ninth Revision, Clinical Modification diagnosis code algorithm.

**RESULTS:** The study cohort comprised 18,279 patients with a mean age of 39 years; 58% were female, and 86% were discharged from an ED. Within 1 year after discharge, 46% had filled an EAI prescription and 29% had A/I follow-up. Overall, from 2005 to 2014, annual rates of filled EAI prescriptions and A/I follow-up did not change. Among children (aged <18 years), rates increased for filled EAI prescriptions (16.1% increase;  $P = .02$  for trend) and A/I follow-up (18.8% increase;  $P = .048$  for trend). Rates decreased for A/I follow-up among adults (15.4% decrease;  $P = .002$  for trend). Overall rates of filled EAI prescriptions were highest in those with venom-induced (73.9 per 100 ED visits) and food-induced anaphylaxis (69.4 per 100 ED visits); the lowest rates were among those with medication-related anaphylaxis (18.2 per 100 ED visits).

**CONCLUSIONS:** Over the past decade, rates of EAI dispensing and A/I follow-up after an ED visit for anaphylaxis have remained low, suggesting that patients may not be prepared to manage future episodes. © 2017 American Academy of Allergy, Asthma & Immunology (J Allergy Clin Immunol Pract 2017;5:1272-9)

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Anaphylaxis is an acute allergic reaction with a rapid onset that may be fatal.<sup>1</sup> For most patients, however, anaphylaxis is a

#### Abbreviations used

A/I- Allergy/immunology  
CI- Confidence interval  
EAI- Epinephrine autoinjector  
ED- Emergency department  
ICD-9-CM- International Classification of Diseases, 9th Revision, Clinical Modification  
ICU- Intensive care unit  
IQR- Interquartile range  
OR- Odds ratio

disorder associated with a chronic risk of relapse. At least 30% of patients with a history of anaphylaxis will have 1 or more recurrences,<sup>2-6</sup> and the subsequent event is unpredictable. In a study of 139 anaphylaxis-related fatalities, 82% of deaths attributed to venom and 78% due to food-induced anaphylaxis occurred in patients without a history of a severe allergic reaction.<sup>7</sup> Because the severity of any anaphylactic event cannot be predicted, measures to prevent future episodes are essential.

Existing national and international guidelines<sup>8,9</sup> agree that comprehensive outpatient anaphylaxis management includes a filled prescription for an epinephrine autoinjector (EAI) and follow-up with an allergy/immunology (A/I) specialist. However, previous single-center and multicenter studies have shown that only 16% to 63% of patients treated in the emergency department (ED) for anaphylaxis received an EAI prescription on discharge from the ED,<sup>10-15</sup> and only 11% to 33% were referred to an A/I specialist.<sup>11,12,14-16</sup>

Although poor rates of EAI dispensing and A/I follow-up have been documented,<sup>17,18</sup> it is not known whether these rates have improved over time. The objective of our study was to evaluate time trends in post-ED outpatient anaphylaxis management by studying EAI dispensing and subsequent A/I follow-up among a nationwide cohort of ED anaphylaxis patients from 2005 through 2014.

## METHODS

### Data source

For our analysis we queried the OptumLabs Data Warehouse, which includes administrative claims data for privately insured and Medicare Advantage enrollees in the United States.<sup>19</sup> This database contains longitudinal health information for more than 100 million enrollees in the past 20 years, from geographically diverse regions of the United States. The data cover several domains, including enrollee information (insurance plan, sex, age, race/ethnicity, dates of eligibility), pharmacy claims (prescribing physician, pharmacy, fill data, days of supply, dosages), and medical claims (including International Classification of Diseases, 9th Revision, Clinical Modification [ICD-9-CM] diagnosis codes, ICD-9 procedure codes, Current Procedural Terminology, Version 4 procedure codes, Healthcare Common Procedure Coding System procedure codes, site of service codes, standardized costs, and provider specialty codes).<sup>20</sup> This study involved analysis of pre-existing, deidentified data and was deemed exempt from institutional review board approval.

### Study population

To identify the analytic cohort of ED visits for anaphylaxis from 2005 to 2014, we used 2 methods validated in a previous study.<sup>21</sup> Method 1 identified patients who had ICD-9-CM diagnosis codes for anaphylactic shock (995.60-995.69 and 995.0). Method 2

identified patients through a validated algorithm of ICD-9-CM codes of symptom combinations.<sup>21</sup> Patients were selected if they had medical and pharmacy coverage at the time of the ED visit and for at least 1 year after the date of ED or hospital discharge, to evaluate whether they filled an EAI prescription (EAI dispensing) and whether they had an A/I follow-up evaluation.

## Methods and measurements

This article adheres to the RECORD (REporting of studies Conducted using Observational Routinely-collected health Data) Statement.<sup>22</sup> We characterized our study population by demographics, anaphylaxis triggers, and ED disposition. Age was grouped into 5 categories: 0-4, 5-17, 18-34, 35-64, and  $\geq 65$  years. Census regions were grouped into the following categories: Midwest, Northeast, South, West, and other/unknown. ED disposition was categorized as ED discharge (including patients with or without observation), inpatient (non-intensive care unit [ICU]) admission, and ICU admission. Postindex prescription EAI dispensing and A/I visits were identified. Time to first EAI dispensing and time to first A/I visit in the postindex period were determined.

## Statistical analysis

Patient characteristics (age, sex, census region) were described using median (interquartile range [IQR]) or count (percentage), as appropriate. Annual rates of filled EAI prescriptions and A/I follow-up were expressed as outcomes per 100 ED visits. We performed linear regression analysis to assess for trends across years. All significance tests were 2-sided, and  $P < .05$  was considered statistically significant. All statistical analyses were performed using SAS software version 9.3 (SAS Institute Inc., Cary, NC). Logistic regression was used to assess the association between A/I follow-up and EAI dispensing, and results are reported as odds ratios (ORs) and 95% confidence intervals (CIs). Because EAI prescription fills and A/I follow-up before the index event may be confounding factors, sensitivity analyses were planned *a priori* and included analysis of time trends after excluding those with prior EAI, A/I follow-up preceding the index event, or both, and also excluding patients who did not have 1 year of medical and pharmacy coverage before the index ED visit.

## RESULTS

### Patient demographics and clinical characteristics

A total of 65,946 unique ED visits for anaphylaxis between 2005 and 2014 were initially identified using method 1 and method 2 of the Harduar-Morano algorithm.<sup>21</sup> After exclusion of patients without medical and pharmacy coverage 1 year after the index event (because of lack of ability to measure their follow-up), 18,279 patients seen in the ED for anaphylaxis were included in our analytic cohort (Figure 1). Patients excluded because of the absence of medical or pharmacy coverage for at least 1 year after the date of ED or hospital discharge were similar to the included cohort with regard to median age (39.0 vs 40.0 years), age group distribution, gender (58.2% vs 58.1% female), trigger, and ED outcomes (data not shown). As shown in Table I, most anaphylaxis ED visits involved patients aged 35 to 64 years (41.9%), and most patients (58.1%) were female. The cohort was primarily from the South (46.9%), followed by the Midwest (25.6%), West (13.7%), and Northeast (13.7%).

### Index event characteristics

Overall, 25.9% of cases were associated with food, 12.2% were medication related, and 4.0% were due to insect venom

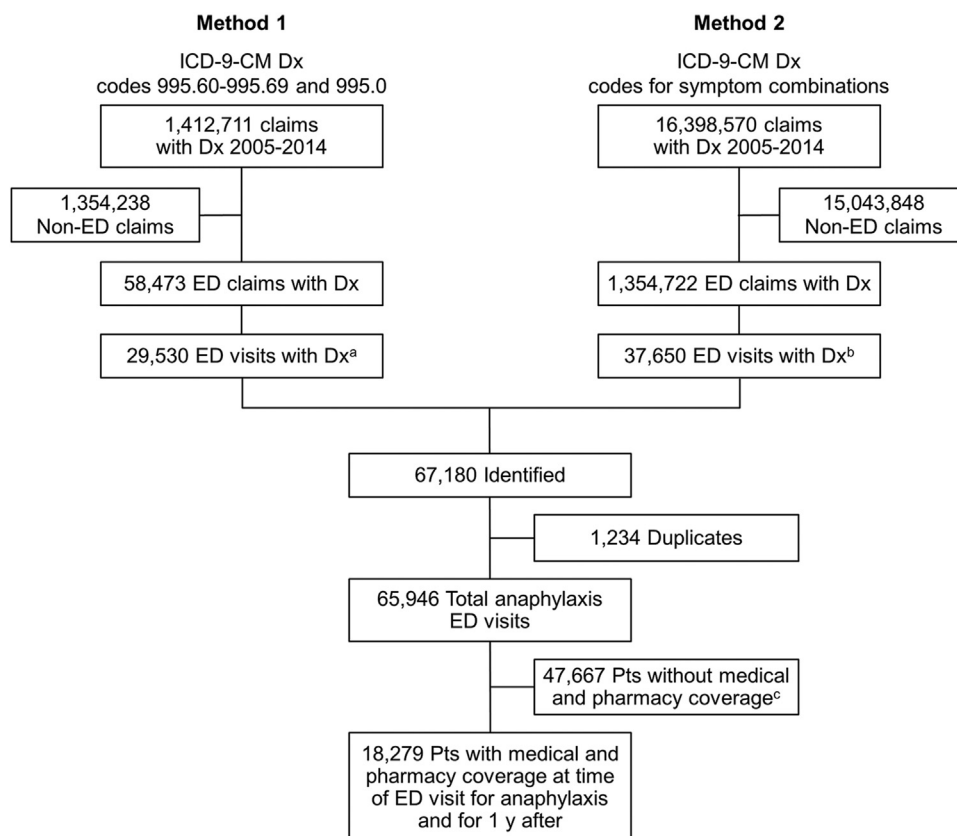


**FIGURE 1.** Flow chart of cohort identification. *Dx*, Diagnosis; *ED*, emergency department; *ICD-9-CM*, International Classification of Diseases, 9th Revision, Clinical Modification; *Pts*, patients. <sup>a</sup>More than 1 claim can be associated with a single ED visit; of the 58,473 claims, only 29,530 represented unique visits. <sup>b</sup>More than 1 claim can be associated with a single ED visit; of the 1,354,722 claims, only 37,650 represented unique visits. <sup>c</sup>Patients without medical and pharmacy coverage for 1 year after the index ED visit were excluded. (Adapted from Motosue MS, Bellolio MF, Van Houten HK, Shah ND, Campbell RL. Increasing emergency department visits for anaphylaxis, 2005-2014. *J Allergy Clin Immunol Pract* 2017;5:171-5.e3. Used with permission.)

(Table I). The remaining cases were caused by unknown or unspecified triggers (57.8%). A majority of patients were discharged from the ED (with or without observation) (85.6%), 7.5% were admitted to the ICU, and the others were non-ICU admissions. A few patients (2.2%) in our cohort underwent endotracheal intubation.

### Rates and time trends of EAI dispensing

Within the 1 year after the index visit, 45.6% of all patients had filled an EAI prescription. Among those patients who filled an EAI prescription within 1 year, most (58.0%) had filled the prescription within 1 day after discharge (Figure 2, A). The median time to the first EAI dispensing was 1 day (IQR, 0-13 days) (Table I).

The overall rates of EAI dispensing remained stable over the 10-year study period ( $P = .17$  for trend), but EAI dispensing rates increased among some patient subgroups (Table II, Figure 3). Rates of filled EAI prescriptions among pediatric patients (<18 years) significantly increased by 16.1%, from 62.9 per 100 ED visits in 2005 to 73.0 per 100 ED visits in 2014 ( $P = .01$  for trend). Similarly, rates of EAI dispensing increased overall among all patients with food-induced anaphylaxis (16.2%;  $P = .03$  for trend), adults with food-induced

anaphylaxis (37.9%;  $P = .01$  for trend), and children with an unspecified trigger (35.4%;  $P = .002$  for trend). Although rates of EAI dispensing among children with food-induced anaphylaxis did not significantly change over the study period, the overall rate was the highest observed (84.0 per 100 ED visits). Similarly, the overall rate of EAI dispensing among those with venom-related anaphylaxis was also high (73.9 per 100 ED visits) but did not significantly change over time. In contrast, the overall rate of EAI dispensing for medication-related anaphylaxis was the lowest (18.2 per 100 ED visits).

### Rates and time trends of A/I follow-up

Within 1 year after the index visit, 29.9% of patients in our cohort had A/I follow-up (Table II). Of those patients with A/I follow-up, a majority of patients (71.2%) had A/I specialty follow-up within 8 weeks after discharge (Figure 2, B). The median time was 24 days (IQR, 8-79 days).

Over the study period, overall rates of A/I follow-up did not significantly change ( $P = .06$ ) (Table II; Figure 3, A). Trends were discordant among patient subgroups, with rates of A/I follow-up decreasing in adults (15.4%;  $P = .002$  for trend) and increasing in children (18.8%;  $P = .048$  for trend) (Figure 3, B and C). A/I follow-up decreased overall among patients with

**TABLE 1.** Characteristics of ED anaphylaxis visits and post-ED visit EAI dispensing and A/I follow-up, 2005-2014 \*

| Characteristic                        | Total (N = 18,279) |
|---------------------------------------|--------------------|
| Age at ED visit, y                    | 40 (19-57)         |
| Age, y                                |                    |
| 0-4                                   | 1,407 (7.7)        |
| 5-17                                  | 2,782 (15.2)       |
| 18-34                                 | 3,530 (19.3)       |
| 35-64                                 | 7,666 (41.9)       |
| ≥65                                   | 2,894 (15.8)       |
| Female sex                            | 10,616 (58.1)      |
| Race                                  |                    |
| Asian                                 | 710 (3.9%)         |
| Black                                 | 2,634 (14.4%)      |
| Hispanic                              | 1,790 (9.8%)       |
| White                                 | 12,162 (66.5%)     |
| Unknown                               | 983 (5.4%)         |
| Census region                         |                    |
| Midwest                               | 4,674 (25.6)       |
| Northeast                             | 2,504 (13.7)       |
| South                                 | 8,564 (46.9)       |
| West                                  | 2,509 (13.7)       |
| Other/unknown                         | 28 (0.1)           |
| Trigger                               |                    |
| Food                                  | 4,742 (25.9)       |
| Medication                            | 2,239 (12.2)       |
| Venom                                 | 725 (4.0)          |
| Unspecified                           | 10,573 (57.8)      |
| ED outcome                            |                    |
| ED discharge or observation           | 15,639 (85.6)      |
| Inpatient admission                   | 1,263 (6.9)        |
| ICU admission                         | 1,377 (7.5)        |
| Endotracheal intubation               | 394 (2.2)          |
| EAI dispensed within 1 y              | 8,339 (45.6)       |
| Time to EAI dispensing, d (n = 8,339) | 1 (0-11)           |
| A/I follow-up within 1 y              | 5,282 (28.9)       |
| Time to A/I follow-up, d (n = 5,282)  | 23 (8-72)          |

A/I, Allergy/immunology; EAI, epinephrine autoinjector; ED, emergency department; ICU, intensive care unit.

\*Values are median (interquartile range) or no. of patients (%).

anaphylaxis due to an unspecified trigger (14.9%;  $P = .01$  for trend) and among the adult subgroup with an unspecified trigger (20.0%;  $P = .01$  for trend). Among all triggers, adult patients with venom- and medication-related anaphylaxis had the lowest rates of A/I follow-up (16.3% and 12.8%, respectively).

Among the 5,282 patients who had an A/I follow-up visit, 3,924 (74.3%) also had EAI dispensed, whereas among the 12,997 patients who did not have an A/I follow-up visit, 4,415 (34.0%) had EAI dispensed. Thus, patients who had an A/I visit were more likely to have an EAI dispensed when compared with those who did not have an A/I follow-up visit (OR 5.62; 95% CI 5.23-6.03).

### Sensitivity analysis

Patients who had been evaluated by an A/I specialist or had filled an EAI prescription in the year before their index ED visit could be less likely to follow up with A/I or fill another EAI

prescription; thus, we performed a sensitivity analysis by excluding these patients. A total of 6,740 patients were excluded from the sensitivity analysis (Table E1, available in this article's Online Repository at [www.jaci-inpractice.org](http://www.jaci-inpractice.org)): 4,757 patients who did not have 1 year of medical and pharmacy coverage before the index ED visit and 1,983 patients who had prior EAI dispensing and/or A/I follow-up (1,868 with prior EAI prescription, 184 with previous A/I follow-up, and 69 with both). Overall, our sensitivity analysis including the other 11,539 patients demonstrated similar time trends based on age groups and outcomes, with one exception. For those with medication-related anaphylaxis, A/I follow-up decreased significantly (35.1% decrease;  $P = .04$  for trend), which was not seen on the initial analysis.

### DISCUSSION

In this contemporary cohort of more than 18,000 patients, we examined time trends of EAI dispensing and visits with an A/I specialist after an ED visit for anaphylaxis. During the 10-year period, only 46% filled an EAI prescription and 29% had A/I follow-up within 1 year after their ED visit. We found striking decreases, particularly in A/I follow-up, among adults and low rates among patients with medication- and venom-related anaphylaxis. To our knowledge, this is the first study to examine time trends of filled EAI prescriptions and A/I follow-up in a nationwide cohort of patients. Our findings suggest that most patients seen in the ED for anaphylaxis may not be prepared to manage a future episode.

Epinephrine is the first-line treatment for anaphylaxis,<sup>8</sup> and delays in epinephrine administration have been associated with fatal outcomes.<sup>23-25</sup> In one of the first national cross-sectional surveys of ED providers, Russell et al<sup>26</sup> reported that less than 50% of providers gave patients a prescription for an EAI or referral to an A/I specialist on discharge. These findings were supported by a patient survey by Wood et al,<sup>27</sup> in which 52% of patients with anaphylaxis reported never having received an EAI prescription. In this same study, despite a majority of patients reporting more than 2 episodes of anaphylaxis in the past, nearly two-thirds of these patients did not plan to use epinephrine for a future reaction.<sup>27</sup> Our study was unable to determine whether the low rates of EAI dispensing were due to ED physicians not prescribing an EAI or patients not filling a prescription. Recent work by Pourang et al<sup>28</sup> examining EAI prescribing and dispensing rates in a health maintenance organization reported an overall low rate of EAI prescribing (16.2% of total cases). However, among cases in which an EAI was prescribed, 95.9% of patients filled the prescription.

The cost of an EAI must also be considered. EpiPens (Mylan) are available as a set of 2, and the average wholesale price for either the 0.15 mg or 0.3 mg dose is US \$730.33.<sup>29</sup> The generic EAI, Adrenaclick, is sold individually at an average wholesale price of US \$103.50 and as a 2-pack for \$206.98.<sup>29</sup> The cost of an EAI is substantial and may represent a patient-specific barrier preventing EAI prescription filling after an ED visit for anaphylaxis. Follow-up studies are needed to address additional knowledge gaps, along with other patient- and provider-specific barriers.

If patients did fill their EAI prescription, most filled it within 1 day after discharge. This is similar to findings by Landsman-Blumberg et al,<sup>17,18</sup> who reported that 71% and 69% of adult

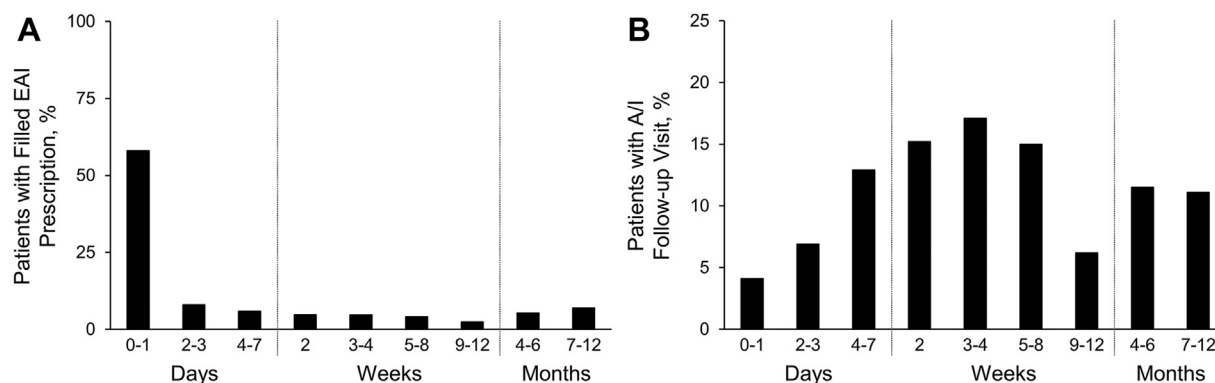


**FIGURE 2.** Timing of epinephrine autoinjector (EAI) dispensing and allergy/immunology (A/I) follow-up. **A**, Time to first EAI dispensing among emergency department (ED) patients who filled an EAI prescription within 1 year after ED anaphylaxis visit ( $n = 8,339$ ). **B**, Time to A/I follow-up visit among ED patients who had A/I follow-up within 1 year after ED anaphylaxis visit ( $n = 5,282$ ).

and pediatric patients, respectively, with food-induced anaphylaxis had filled an EAI prescription within 1 week after ED discharge. The index ED event may thus represent a unique time at which providers may be the most influential in motivating patients to fill their EAI prescriptions. Moreover, it is clinically important for patients to have an EAI soon after ED discharge because biphasic reactions can occur up to 72 hours after the initial reaction.<sup>30,31</sup> ED-based strategies geared toward increased EAI prescribing and dispensing are needed to take advantage of this patient opportunity. In addition, research into the effectiveness of alternative strategies, such as EAI provision on discharge, should be examined with follow-up cost-benefit analyses.<sup>18</sup>

Nearly 70% of patients in our cohort did not have A/I follow-up. In a retrospective study of ED patients with anaphylaxis, Campbell et al<sup>32</sup> showed that, after A/I evaluation, the diagnosis or suspected anaphylaxis trigger was altered in 35% of patients. A/I specialists also provide comprehensive risk assessment and develop personalized risk-reduction strategies.<sup>33</sup> In our cohort, the lowest rates of A/I follow-up were among those with venom-related anaphylaxis. This is unfortunate because these patients would be potential candidates for venom immunotherapy, which has been shown to provide lasting protection and almost entirely prevent future systemic reactions.<sup>34-36</sup> Patients with a history of systemic anaphylaxis to venom should be evaluated for underlying mastocytosis, a diagnosis associated with a high risk of recurrent anaphylaxis among other complications.<sup>8</sup> Follow-up with an A/I specialist would help to address these issues.

By closely examining rates according to adult versus pediatric subgroups, we found higher rates of EAI dispensing and A/I follow-up among children compared with adults. Kaplan et al<sup>37</sup> found similar results in their study examining refill history in 14,677 patients. Infants and children 12 years and younger were more likely to have their EAI refilled (63%) than were teenagers and adults (40%). The reason for this may be that allergy management for children is primarily overseen by parents and caregivers.<sup>38</sup> Caregiver support has been associated with improved outcomes related to treatment adherence in various chronic conditions, including cardiac disease<sup>39</sup> and chronic obstructive pulmonary disease.<sup>40</sup> Given that a high proportion of patients with food-induced anaphylaxis are children, the effect of caregiver support may explain the higher overall rates of filled

EAI prescriptions and A/I follow-up among those with food-induced anaphylaxis.

Patients with venom-related anaphylaxis also had higher overall rates of filled EAI prescriptions, ranging from 64% to 80%. This is similar to rates in a previous study by Rudders et al,<sup>36</sup> who reported that approximately 69% of 954 patients with venom-related anaphylaxis filled an EAI prescription during the postindex period. Work by Campbell et al<sup>10</sup> supports these findings—venom-related anaphylaxis was associated with increased odds of receiving an EAI prescription (odds ratio, 4.0). One reason may be that venom as a trigger may be more obvious than other triggers, which makes the diagnosis and the need for an EAI relatively straightforward for both the physician and the patient. However, other reasons for this trend are unclear, and additional studies are needed to verify and further explain these trends.

### Limitations

Potential limitations of this study are similar to other studies based on ICD-9-CM coding. First, there is a possibility of misreporting and underreporting of cases. However, we attempted to minimize this by using an additional algorithm that combined ICD-9-CM codes for symptoms. Second, the study population comprised those with at least 1 continuous year of Medicare Advantage and private insurance, and our findings may not be applicable to those with Medicaid, Medicare fee-for-service, or uninsured populations. Third, the use of claims data does not allow us to determine if low rates of EAI dispensing or A/I follow-up were due to the lack of provision of an EAI prescription or referral to an allergist or if they were due to poor patient adherence to physician recommendations. Fourth, a large proportion of cases did not have a specified trigger. It is unclear whether these data represent unknown triggers after evaluation or missing information about the triggers. Lastly, we could not eliminate the effects of unmeasured confounders.

In contrast, strengths of our study include a large sample size that included both academic and nonacademic institutions and the use of real-world data; thus, our data are most likely generalizable to other commercially insured patients in the United States. In addition, we used rigorous methodology in the selection of our patients and in our data analysis measuring time

**TABLE II.** Rates of EAI dispensing and A/I follow-up within 1 y after ED anaphylaxis visit, 2005-2014\*

| Category                       | Year |       |      |      |      |      |      |       |      |       | Overall | Percentage change | P value |
|--------------------------------|------|-------|------|------|------|------|------|-------|------|-------|---------|-------------------|---------|
|                                | 2005 | 2006  | 2007 | 2008 | 2009 | 2010 | 2011 | 2012  | 2013 | 2014  |         |                   |         |
| Overall                        |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| EAI dispensing                 | 42.7 | 46.4  | 44.6 | 43.7 | 43.5 | 44.2 | 46.8 | 46.4  | 50.2 | 44.0  | 45.6    | 3.0               | .17     |
| Mean time to EAI dispensing, d | 35.9 | 31.1  | 29.6 | 31.5 | 26.9 | 30.9 | 29.7 | 30.5  | 34.2 | 26.9  | 30.8    | −25.1             | .30     |
| A/I follow-up                  | 31.1 | 31.4  | 29.0 | 28.8 | 28.3 | 27.0 | 28.2 | 29.2  | 29.0 | 28.5  | 28.9    | −8.4              | .06     |
| Mean time to A/I follow-up, d  | 59.3 | 55.5  | 55.0 | 57.0 | 58.1 | 66.1 | 64.8 | 62.9  | 64.8 | 57.5  | 60.8    | −3.0              | .12     |
| Children                       |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| EAI dispensing                 | 62.9 | 72.2  | 65.4 | 64.8 | 72.6 | 69.9 | 76.2 | 72.5  | 77.2 | 73.0  | 71.3    | 16.1              | .01     |
| A/I follow-up                  | 48.9 | 49.7  | 46.6 | 46.1 | 47.8 | 45.7 | 49.4 | 48.8  | 52.0 | 58.1  | 49.1    | 18.8              | .048    |
| Adults                         |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| EAI dispensing                 | 35.4 | 38.5  | 37.9 | 37.4 | 35.9 | 37.2 | 38.4 | 38.6  | 41.3 | 36.6  | 38.0    | 3.4               | .25     |
| A/I follow-up                  | 24.7 | 25.9  | 23.4 | 23.6 | 23.2 | 21.9 | 22.2 | 23.3  | 21.4 | 20.9  | 22.9    | −15.4             | .002    |
| Food trigger                   |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| Overall                        |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| EAI dispensing                 | 59.9 | 68.3  | 69.2 | 67.1 | 71.9 | 66.7 | 70.6 | 71.1  | 72.9 | 69.6  | 69.4    | 16.2              | .03     |
| A/I follow-up                  | 39.5 | 41.3  | 40.2 | 40.7 | 39.3 | 38.7 | 38.9 | 40.2  | 38.8 | 41.8  | 39.8    | 5.8               | .85     |
| Children                       |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| EAI dispensing                 | 77.3 | 82.5  | 85.3 | 81.1 | 88.8 | 83.7 | 87.5 | 82.5  | 86.3 | 80.0  | 84.0    | 3.5               | .38     |
| A/I follow-up                  | 54.5 | 55.7  | 52.8 | 54.7 | 51.7 | 52.6 | 55.9 | 51.4  | 54.5 | 60.0  | 54.1    | 10.1              | .39     |
| Adults                         |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| EAI dispensing                 | 44.1 | 54.9  | 57.3 | 55.0 | 58.2 | 54.1 | 56.0 | 60.9  | 59.3 | 60.8  | 56.7    | 37.9              | .01     |
| A/I follow-up                  | 25.9 | 27.7  | 30.9 | 28.6 | 29.1 | 28.6 | 24.1 | 30.2  | 22.8 | 26.3  | 27.3    | 1.5               | .32     |
| Medication trigger             |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| Overall                        |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| EAI dispensing                 | 24.3 | 17.3  | 18.1 | 17.8 | 14.8 | 16.6 | 17.9 | 17.8  | 20.2 | 24.4  | 18.2    | 0.4               | .83     |
| A/I follow-up                  | 15.7 | 20.2  | 17.2 | 10.9 | 12.1 | 14.7 | 12.9 | 13.7  | 13.9 | 16.3  | 14.1    | 0.0               | .48     |
| Children                       |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| EAI dispensing                 | 42.9 | 16.7  | 33.3 | 18.2 | 20.0 | 25.0 | 32.0 | 50.0  | 31.6 | 42.9  | 30.6    | 0.0               | .75     |
| A/I follow-up                  | 42.9 | 33.3  | 25.9 | 13.6 | 24.0 | 25.0 | 28.0 | 50.0  | 26.3 | 42.9  | 28.9    | 0.0               | .59     |
| Adults                         |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| EAI dispensing                 | 22.2 | 17.3  | 16.0 | 17.8 | 14.3 | 15.9 | 16.7 | 15.6  | 19.3 | 23.4  | 17.1    | 5.4               | .61     |
| A/I follow-up                  | 12.7 | 19.4  | 16.0 | 10.7 | 10.9 | 13.9 | 11.6 | 11.2  | 12.9 | 14.8  | 12.8    | 16.5              | .53     |
| Venom trigger                  |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| Overall                        |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| EAI dispensing                 | 63.5 | 71.9  | 73.8 | 78.8 | 67.9 | 79.5 | 70.1 | 79.5  | 78.9 | 72.7  | 73.9    | 14.5              | .16     |
| A/I follow-up                  | 17.6 | 22.8  | 18.8 | 15.2 | 21.8 | 18.1 | 8.0  | 24.1  | 24.2 | 4.5   | 18.5    | −74.4             | .41     |
| Children                       |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| EAI dispensing                 | 64.7 | 100.0 | 57.1 | 77.8 | 66.7 | 90.0 | 90.9 | 100.0 | 80.0 | 100.0 | 78.5    | 54.6              | .12     |
| A/I follow-up                  | 23.5 | 28.6  | 28.6 | 22.2 | 25.0 | 50.0 | 27.3 | 27.3  | 46.7 | 0.0   | 30.8    | −100.0            | .85     |
| Adults                         |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| EAI dispensing                 | 63.2 | 68.0  | 77.3 | 78.9 | 68.2 | 78.1 | 67.1 | 76.4  | 78.8 | 71.4  | 73.1    | 13.0              | .28     |
| A/I follow-up                  | 15.8 | 22.0  | 16.7 | 14.0 | 21.2 | 13.7 | 5.3  | 23.6  | 20.0 | 4.8   | 16.3    | −69.6             | .38     |
| Unspecified trigger            |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| Overall                        |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| EAI dispensing                 | 34.5 | 38.2  | 37.8 | 37.9 | 37.1 | 39.0 | 41.4 | 39.4  | 42.4 | 35.9  | 38.8    | 4.1               | .19     |
| A/I follow-up                  | 30.2 | 28.9  | 28.0 | 29.2 | 28.5 | 25.8 | 28.4 | 27.8  | 27.1 | 25.7  | 27.9    | −14.9             | .01     |
| Children                       |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| EAI dispensing                 | 47.4 | 57.5  | 52.8 | 51.5 | 58.9 | 59.7 | 65.4 | 59.3  | 66.5 | 64.2  | 58.8    | 35.4              | .002    |
| A/I follow-up                  | 46.0 | 42.5  | 45.5 | 41.7 | 48.2 | 40.8 | 44.4 | 46.2  | 50.7 | 56.8  | 45.9    | 23.5              | .08     |
| Adults                         |      |       |      |      |      |      |      |       |      |       |         |                   |         |
| EAI dispensing                 | 31.5 | 34.9  | 34.2 | 35.1 | 33.6 | 34.8 | 37.0 | 35.6  | 37.8 | 31.8  | 35.0    | 1.0               | .36     |
| A/I follow-up                  | 26.5 | 26.6  | 23.7 | 26.6 | 25.3 | 22.7 | 25.5 | 24.3  | 22.7 | 21.2  | 24.4    | −20.0             | .01     |

A/I, Allergy/immunology; EAI, epinephrine autoinjector; ED, emergency department.

\*Values are no. per 100 ED visits for anaphylaxis, unless otherwise specified.

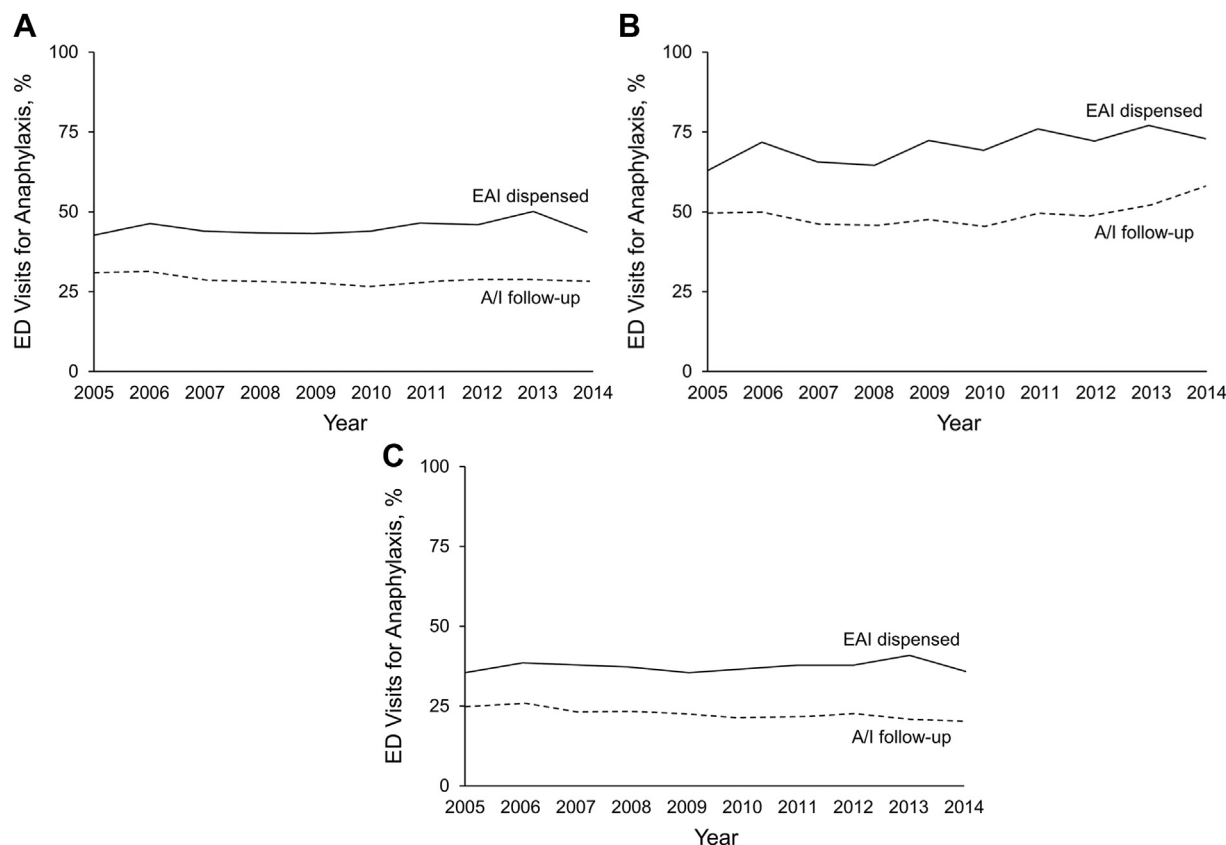


**FIGURE 3.** Trends in emergency department (ED) patient epinephrine autoinjector (EAI) dispensing and allergy/immunology (A/I) follow-up within 1 year after ED anaphylaxis visit, 2005-2014. **A**, Overall rates. **B**, Rates in children (aged 0-17 years). **C**, Rates in adults (aged ≥18 years).

trends of EAI and A/I follow-up. Sensitivity analysis was also performed to exclude the effects of prior EAI dispensing and A/I follow-up and revealed similar time trends, which further reinforces our findings.

## CONCLUSIONS

Appropriate anaphylaxis management extends beyond the acute event and, as with any chronic diagnosis, follow-up and long-term risk reduction are necessary. Over the past decade, EAI dispensing and A/I follow-up after an ED anaphylaxis visit have remained suboptimal. Additional studies are needed to identify system-based and patient barriers and thereby guide strategies for improvement.

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## ONLINE REPOSITORY

**TABLE E1.** Rates of EAI dispensing and A/I follow-up within 1 y after ED anaphylaxis visit, excluding patients with EAI and/or A/I follow-up within prior 12 mo, 2005-2014\*

| Category            | Year |       |      |      |      |      |      |       |      |      | Percentage change | P value |
|---------------------|------|-------|------|------|------|------|------|-------|------|------|-------------------|---------|
|                     | 2005 | 2006  | 2007 | 2008 | 2009 | 2010 | 2011 | 2012  | 2013 | 2014 |                   |         |
| Overall             |      |       |      |      |      |      |      |       |      |      |                   |         |
| EAI dispensing      | 37.6 | 43.0  | 43.1 | 41.0 | 40.9 | 38.6 | 43.8 | 42.8  | 44.4 | 38.0 | 1.1               | .72     |
| A/I follow-up       | 28.1 | 29.1  | 27.5 | 26.2 | 24.9 | 24.1 | 24.8 | 25.1  | 24.5 | 24.1 | −14.2             | .001    |
| Children            |      |       |      |      |      |      |      |       |      |      |                   |         |
| EAI dispensing      | 57.7 | 71.4  | 62.2 | 58.5 | 72.1 | 61.2 | 72.8 | 69.0  | 68.3 | 66.9 | 15.9              | .24     |
| A/I follow-up       | 42.3 | 45.5  | 44.7 | 42.0 | 47.1 | 43.2 | 47.1 | 45.0  | 47.9 | 55.1 | 30.3              | .02     |
| Adults              |      |       |      |      |      |      |      |       |      |      |                   |         |
| EAI dispensing      | 31.2 | 36.5  | 38.3 | 36.7 | 34.1 | 33.7 | 37.5 | 37.9  | 38.9 | 32.9 | 5.4               | .53     |
| A/I follow-up       | 23.5 | 25.3  | 23.2 | 22.4 | 20.1 | 19.9 | 20.0 | 21.3  | 19.1 | 18.7 | −20.4             | <.001   |
| Food trigger        |      |       |      |      |      |      |      |       |      |      |                   |         |
| Overall             |      |       |      |      |      |      |      |       |      |      |                   |         |
| EAI dispensing      | 54.3 | 62.1  | 69.6 | 66.8 | 70.8 | 61.1 | 68.0 | 67.0  | 67.3 | 63.4 | 16.8              | .29     |
| A/I follow-up       | 34.3 | 35.9  | 42.9 | 37.7 | 37.3 | 35.0 | 35.4 | 37.1  | 32.7 | 37.1 | 8.2               | .52     |
| Children            |      |       |      |      |      |      |      |       |      |      |                   |         |
| EAI dispensing      | 74.0 | 82.1  | 89.7 | 80.9 | 90.5 | 78.9 | 85.4 | 78.7  | 81.0 | 78.8 | 6.5               | .87     |
| A/I follow-up       | 45.2 | 51.3  | 52.9 | 57.3 | 53.3 | 48.9 | 56.2 | 51.5  | 53.3 | 56.1 | 24.1              | .15     |
| Adults              |      |       |      |      |      |      |      |       |      |      |                   |         |
| EAI dispensing      | 40.2 | 49.2  | 57.8 | 57.3 | 57.4 | 51.5 | 57.7 | 60.6  | 58.8 | 54.1 | 34.6              | .06     |
| A/I follow-up       | 26.5 | 25.8  | 37.1 | 24.4 | 26.5 | 27.5 | 23.2 | 29.3  | 19.9 | 25.7 | −3.0              | .29     |
| Medication trigger  |      |       |      |      |      |      |      |       |      |      |                   |         |
| Overall             |      |       |      |      |      |      |      |       |      |      |                   |         |
| EAI dispensing      | 23.4 | 16.7  | 17.6 | 16.2 | 13.6 | 12.8 | 16.7 | 15.2  | 17.0 | 21.0 | −10.3             | .62     |
| A/I follow-up       | 19.1 | 19.4  | 15.5 | 9.2  | 12.1 | 12.2 | 11.0 | 12.5  | 12.6 | 12.4 | −35.1             | .04     |
| Children            |      |       |      |      |      |      |      |       |      |      |                   |         |
| EAI dispensing      | 42.9 | 0.0   | 29.4 | 15.8 | 21.4 | 21.4 | 31.6 | 36.4  | 21.4 | 0.0  | −100.0            | .49     |
| A/I follow-up       | 42.9 | 33.3  | 11.8 | 10.5 | 14.3 | 21.4 | 26.3 | 36.4  | 28.6 | 0.0  | −100.0            | .93     |
| Adults              |      |       |      |      |      |      |      |       |      |      |                   |         |
| EAI dispensing      | 20.0 | 17.4  | 16.0 | 16.2 | 13.0 | 12.1 | 15.3 | 14.3  | 16.7 | 21.8 | 9.0               | .98     |
| A/I follow-up       | 15.0 | 18.8  | 16.0 | 9.1  | 12.0 | 11.5 | 9.6  | 11.5  | 11.3 | 12.9 | −14.0             | .09     |
| Venom trigger       |      |       |      |      |      |      |      |       |      |      |                   |         |
| Overall             |      |       |      |      |      |      |      |       |      |      |                   |         |
| EAI dispensing      | 56.8 | 77.8  | 79.2 | 79.1 | 70.9 | 84.2 | 72.7 | 83.1  | 77.0 | 83.3 | 46.7              | .10     |
| A/I follow-up       | 15.9 | 25.0  | 17.0 | 16.3 | 21.8 | 14.0 | 4.5  | 15.3  | 19.7 | 8.3  | −47.8             | .16     |
| Children            |      |       |      |      |      |      |      |       |      |      |                   |         |
| EAI dispensing      | 63.6 | 100.0 | 71.4 | 83.3 | 70.0 | 88.9 | 88.9 | 100.0 | 72.7 | 0.0  | −100.0            | .49     |
| A/I follow-up       | 36.4 | 0.0   | 28.6 | 33.3 | 30.0 | 44.4 | 22.2 | 22.2  | 36.4 | 0.0  | −100.0            | .61     |
| Adults              |      |       |      |      |      |      |      |       |      |      |                   |         |
| EAI dispensing      | 54.5 | 75.8  | 80.4 | 78.4 | 71.1 | 83.3 | 70.2 | 80.0  | 78.0 | 83.3 | 52.8              | .10     |
| A/I follow-up       | 9.1  | 27.3  | 15.2 | 13.5 | 20.0 | 8.3  | 1.8  | 14.0  | 16.0 | 8.3  | −8.8              | .31     |
| Unspecified trigger |      |       |      |      |      |      |      |       |      |      |                   |         |
| Overall             |      |       |      |      |      |      |      |       |      |      |                   |         |
| EAI dispensing      | 30.8 | 36.9  | 37.5 | 36.1 | 34.7 | 34.0 | 39.1 | 38.4  | 38.9 | 31.5 | 2.3               | .57     |
| A/I follow-up       | 27.8 | 28.1  | 26.5 | 27.5 | 24.1 | 24.1 | 25.7 | 24.3  | 24.0 | 22.4 | −19.4             | <.001   |
| Children            |      |       |      |      |      |      |      |       |      |      |                   |         |
| EAI dispensing      | 44.0 | 61.4  | 47.9 | 44.0 | 57.0 | 50.0 | 64.0 | 58.3  | 59.4 | 56.3 | 28.0              | .13     |
| A/I follow-up       | 40.5 | 41.4  | 45.8 | 34.1 | 46.8 | 41.2 | 42.1 | 40.0  | 45.3 | 58.3 | 44.0              | .13     |
| Adults              |      |       |      |      |      |      |      |       |      |      |                   |         |
| EAI dispensing      | 27.8 | 33.1  | 35.3 | 34.7 | 31.6 | 31.2 | 35.4 | 35.8  | 35.7 | 28.9 | 4.0               | .58     |
| A/I follow-up       | 24.9 | 26.0  | 22.6 | 26.4 | 21.0 | 21.1 | 23.3 | 22.3  | 20.6 | 18.5 | −25.7             | .009    |

A/I, Allergy/immunology; EAI, epinephrine autoinjector; ED, emergency department.

\*Values are no. per 100 ED visits for anaphylaxis.

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