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SYRINGE ADMINISTRATION OF EPINEPHRINE BY EMERGENCY MEDICAL TECHNICIANS FOR ANAPHYLAXIS

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ABSTRACT

Objective: In recent years, the costs of epinephrine autoinjectors (EAI) in the United States have risen substantially. King County Emergency Medical Services implemented the “Check and Inject” program to replace EAI by teaching emergency medical technicians (EMTs) to manually aspirate epinephrine from a single-use 1 mg/mL epinephrine vial using a needle and syringe followed by prehospital intramuscular administration of the correct adult or pediatric dose of epinephrine for anaphylaxis or serious allergic reaction. Treatment was guided by an EMT protocol that required a trigger and symptoms. We sought to determine if the “Check and Inject” program was safely implemented by EMTs treating presumed prehospital anaphylaxis or serious allergic reaction. **Methods:** We conducted a prospective investigation of all cases treated as part of the “Check and Inject” program from July 2014 through December 2016 in suburban King County, Washington, and January 2016 through December 2016 within the city of Seattle. All cases were prospectively collected using a custom quality improvement data

form completed by the first responding EMTs. Two physicians completed a structured review of each EMS medical record to determine if the EMTs followed the Check and Inject protocol and determine if epinephrine was clinically indicated based on physician review. **Results:** Of the 411 cases eligible for analysis, EMTs followed the protocol appropriately in 367 (89.3%) cases. In the remaining 44 (10.7%) cases, the EMS incident report form failed to document either a clear inciting allergic trigger or an appropriate symptom from the protocol list. Physician review determined that epinephrine was clinically indicated in 36 of the 44 cases. Among the remaining 8 cases (1.9%) that did not meet protocol criteria and were not clinically-indicated based on physician review, none had a documented adverse reaction to the epinephrine. **Conclusion:** We observed that EMTs successfully implemented the manual “Check and Inject” program for severe allergic reactions and anaphylaxis in a manner that typically agreed with physician review and without any overt identified safety issues. **Key words:** emergency medical services; emergency medical technicians; epinephrine; anaphylaxis; allergic reaction; prehospital emergency care

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INTRODUCTION

Anaphylaxis is a severe, potentially life-threatening reaction to an allergic trigger characterized by a release of histamine resulting in bronchoconstriction, edema, hypotension, and circulatory compromise (1). Encounters with Emergency Medical Services (EMS) for anaphylaxis appear to be increasing, especially among children (2–4). The cornerstone of therapy for anaphylaxis is early treatment with intramuscular epinephrine, and delays to treatment are associated with increased risk of death (5, 6). The National Association of EMS Physicians (NAEMSP) believes that EMS professionals should be able to identify and treat anaphylaxis in the prehospital setting with appropriate medical oversight, and many states have legislation requiring that Emergency Medical Technicians (EMTs) are trained and equipped to administer epinephrine in the form of an autoinjector (EAI) (7–9). While EAI require minimal training, the rising costs of EAI have created a significant financial burden for EMS agencies (10–12). EAI have risks, including accidental injection of the rescuer and injuries to the patient, especially in the pediatric population (13, 14).

Since 2000, EMTs in King County, Washington, have been trained and equipped to administer EAI to

patients with suspected anaphylaxis (9). In response to rising costs of EAs, King County Emergency Medical Services (KC EMS) implemented a program in 2014 called “Check and Inject” to train EMTs to safely aspirate epinephrine from a single-use 1 mg/mL epinephrine vial using a needle and syringe followed by prehospital intramuscular (IM) administration of the correct adult or pediatric dose of epinephrine for suspected anaphylaxis or severe allergic reaction. This investigation of the King County experience over the first two and a half years of the “Check and Inject” program sought to determine if intramuscular epinephrine was being administered correctly and in a clinically appropriate manner by EMTs for prehospital treatment of anaphylaxis and severe allergic reaction.

METHODS

Design, Population, and Setting

Cases were collected prospectively when patients were treated by EMTs with IM epinephrine as part of the KC EMS “Check and Inject” program. Training for the program began April 1, 2014 and all of the approximately 2,700 EMTs in the County, with the exception of the Seattle Fire Department, were trained by June 20, 2014. Training of approximately 800 more EMTs in the city of Seattle was completed in December 2015. The current study included cases from July 2014 through December 2016 in greater King County and January 2016 through December 2016 in the city of Seattle. The study was approved by the University of Washington Institutional Review Board.

King County, including Seattle, covers approximately 2,300 square miles with a population of approximately 2.1 million persons (15). King County is comprised of urban, suburban, and rural areas and is served by a two-tiered EMS response system. The first response tier for medical emergencies is made up of EMTs providing a basic life support (BLS) level of medical care and employed by 26 different agencies. Depending on the nature of the medical call, a second tier comprised of about 250 mobile intensive care paramedics from 5 different agencies may be simultaneously dispatched. In these cases, the first tier EMTs typically arrive 5 or more minutes prior to the second-tier intensive care paramedics. The first tier EMTs can also evaluate the patient on scene and request the dispatch of an intensive care paramedic unit depending on the condition of the patient.

EMT IM Epinephrine Protocol, Equipment, and Training

The King County “Check and Inject” protocol for EMT treatment of anaphylaxis involves identifying a patient with a potential severe allergic reaction,

verifying a trigger (a food allergy, an insect sting, or a drug allergy), and confirming severe symptoms (respiratory distress, facial/oropharyngeal swelling, hypotension, and/or diffuse or progressive hives) (Figure 1). Following training, the EMTs were issued a “Check and Inject” kit that includes a 1-mL vial of 1 mg/mL epinephrine, two 1-mL syringes with attached 25 g safety needles, adhesive bandages, alcohol wipes, and a form printed on card-stock with the KC EMS protocol and appropriate steps with illustrations (Figure 1) housed inside of a small plastic case. During the study period, King County EMS assembled the kit for an estimated cost of \$18 each. If epinephrine is administered, the protocol requires activation of a second tier paramedic unit—if not already dispatched—for evaluation and transport of the patient. The “Check and Inject” protocol permits repeat administration of IM epinephrine by EMTs every five minutes if the patient does not clinically improve or continues to deteriorate.

Prior to implementation of this program, each EMT was required to successfully complete a training course. Training included definition and identification of anaphylaxis and how to administer intramuscular epinephrine. The required training was lecture-based with printed handout materials and an in-person practical session that included orientation to the kit and time with a senior instructor who observed the EMT correctly draw-up and administer the epinephrine into either a manikin or an orange. The training time for the “Check and Inject” program EMTs was about 2 hours including the didactic and hands-on portion with the kit and a competency demonstration in front of instructors. EMT-Bs in King County and Washington State in general complete standardized EMT training leading to Washington State certification and many in addition carry a standard NREMT credential. There were approximately 3,500 EMTs trained to administer IM epinephrine as part of the “Check and Inject Program” in King County over the study period.

An ongoing quality improvement (QI) program within King County EMS evaluates a number of BLS and paramedic skills and responses to selected emergency calls. Quality improvement for the “Check and Inject” program included a special notification to King County EMS every time a kit was used. After the medical incident, the EMT contacts KC EMS by phone to log the “Check and Inject” usage and coordinate with a KC EMS representative to return materials and information. The contact provides opportunity to highlight any potential challenge or safety issue noted during the course of care. The EMT then returns the used kit with the remaining medication, a copy of the medical incident report form, and quality improvement data forms to order a new replacement kit.

CHECK & INJECT EMT Epinephrine Injection Process				
MEETS CRITERIA ☐ VERIFY NEED TRIGGER • food allergy • insect sting • drug allergy SYMPTOMS • respiratory distress • hypotension • hives ◦ diffuse ◦ progressive	VERIFY DRUG ☐ CONFIRM MEDS • 1:1000 Epinephrine • expiration date • contents: ◦ clear	VERIFY DOSAGE ☐ DRAW UP DOSE & CONFIRM DRUG IN SYRINGE Adult = 0.3 cc  Peds < 66 lbs = 0.15 cc 	PREP & INJECT ☐ PREP PATIENT • Clean injection site ◦ lateral thigh ◦ alcohol wipe • Insert needle ◦ 90 degrees ◦ lack of blood return • Push plunger • Remove syringe • Activate safety device • Massage site - 30 sec.	MONITOR & RECORD ☐ MONITOR & DOCUMENT • Reassure patient • Monitor for: ◦ response ◦ side effects • Provide oxygen for respiratory distress • Monitor every 5 min. • Update medics on: ◦ patient status ◦ response to injection • Document ◦ date ◦ dose ◦ time ◦ location ◦ patient response
Date _____ Inc # _____ EMT 1 _____ EMT 2 _____				

FIGURE 1. "Check and Inject" protocol as documented inside kit supplied to EMS.

Data Collection and Analysis

Cases were identified by the phone log and the return of the kits and forms to KC EMS. In addition, a search was conducted through the county-wide electronic records database for any recorded BLS administration of epinephrine. Data were abstracted from the incident report form and the quality improvement data forms retrieved from the EMT units. The medical incident report includes patient demographics, medications, allergies, a narrative of the history of present illness, physical examination including vital signs, EMS response intervals, the EMT-determined diagnostic category of the incident, care provided, patient response to care, and patient disposition. Information was also abstracted about the potential triggers of the patient's condition as well as their signs and symptoms.

After abstraction, each incident report form was independently reviewed by two physicians (AL, ME) with experience in treating severe allergic reactions and anaphylaxis to assess if EMT epinephrine administration adhered to the "Check and Inject" protocol and whether epinephrine administration was appropriate per physician clinical assessment. The reviewing physicians utilized the 2013 American College of Emergency Physicians (ACEP) recommended definition of anaphylaxis as well as their clinical judgment (16). If the assessment by the two physicians was discordant, the event was discussed until a consensus was reached.

RESULTS

Of the 422 cases of EMT-B epinephrine administration during the study period, 11 were excluded due to inability to recover the incident report form for review. Table 1 presents the characteristics of the 411 cases of EMT "Check and Inject" administration included in the analysis. A slight majority of patients were female, and most patients were between the ages of 15 and 64. In 8.0% of cases, epinephrine was administered prior to EMS arrival. Nuts were the most common documented allergic trigger, followed by other foods, and bee stings. Approximately 76.6% of patients had more than one serious allergic symptom or sign. The most common symptoms/signs were severe or progressive hives, swelling of the face/oropharynx, and respiratory distress. Hypotension (defined as systolic blood pressure <90 mmHg) was present in 25.8% of patients. 92.5% of patients had at least one abnormal vital sign prior to administration of epinephrine. Approximately 9.5% of patients received a second dose of EMS epinephrine, delivered either by the EMTs or paramedics.

Table 2 presents the results of the epinephrine administration in a 2 × 2 format according to protocol criteria and clinical indication based on physician review. Of the included cases, physician review determined that the EMTs followed the "Check and Inject" protocol appropriately by identifying a patient with both an allergic trigger and severe symptoms in 89.3% of cases.

TABLE 1. Case Demographics

Characteristic	N (%)
Gender	
Male	182 (44.3)
Female	229 (55.7)
Age	
<5 yo	33 (8.0)
5–14 yo	40 (9.7)
15–64 yo	299 (72.7)
≥65 yo	39 (9.5)
Epi was administered prior to EMS arrival	33 (8.0)
Patient/Family	25 (6.1)
Healthcare Provider	6 (1.5)
Other	2 (0.5)
Triggers	
Food – Nuts	92 (22.4)
Food – Shellfish	28 (6.8)
Food – Other	83 (20.2)
Drug – NSAIDs	8 (1.9)
Drug – Antibiotics	26 (6.3)
Drug – Other	35 (8.5)
Insect Sting – Bee	59 (14.4)
Insect Sting – Other	13 (3.2)
Other/Environmental	24 (5.8)
Not documented/Unknown	43 (10.5)
Vital Signs (Prior to administration of IM epi)	
Respiratory Rate, mean per minute (SD) [†]	22 (7.5) [*]
Respiratory Rate, ≥20 respirations/min [*]	223 (67.2) [*]
Pulse Rate, mean per minute (SD) [†]	104 (23.1) [†]
Pulse Rate, ≥100 bpm [†]	226 (63.5) [†]
Pulse Rate, ≤60 bpm [†]	14 (4.0) [†]
Any abnormal vital sign prior to epinephrine administration ^o	380 (92.5) ^o
Symptoms/Signs	
Hypotension (BP ≤90)	106 (25.8)
Hives	241 (58.6)
Respiratory Distress	188 (45.7)
Swelling of the face, lips, or oropharynx	189 (46.0)
Number of symptoms	
Patients with only 1 symptom	63 (15.3)
Patients with 2 or more symptoms	315 (76.6)
Second Dose administered after EMTs administered one dose of epi	
Yes	39 (9.5)
No	367 (89.3)
Received an ALS evaluation	
Yes	377 (91.7)
No	34 (8.3)

*Based on 332 cases where a respiratory rate was documented prior to epi administration.

[†]Based on 356 cases where a pulse rate was documented prior to epi administration.

^oBP ≤90, or pulse ≥100 bpm, or respiratory rate ≥20 resp/min, or SpO₂ ≤90%. Out of 411 cases.

TABLE 2. Clinical Indication vs. Protocol Adherence (n = 411 cases)

		Clinically Indicated Based on Physician Review	
		Yes	No
Followed “Check and Inject” Protocol	Yes	355 (86%)	12 (3%)
	No	36 (9%)	8 (2%)

In the remaining 10.7% of cases ($n = 44$), the EMS incident report form failed to document either a clear inciting allergic trigger or an appropriate severe symptom from the protocol symptom list. The majority of these cases were due to an unclear or un-documented allergic trigger. Of these 44 cases, physician review determined that epinephrine was clinically indicated in 36 cases.

Of the 411 cases, there were 20 cases (4.9%) in which physician review determined that epinephrine was not indicated; however, 12 met “Check and Inject” criteria. Many of these were cases of progressive urticaria with a clear trigger that physician review determined did not meet severity criteria. There were 8 cases with both a potential breach in administration protocol and in which physician review concluded the epinephrine was not clinically indicated. There were no overt identified patient or EMT safety issues in these cases, such as the development of chest pain, new hypertension (SBP > 160) or tachycardia (HR > 140), irregular heart rate, or needle stick injuries based on review of the EMS incident report form or from the case-specific EMT feedback.

Figure 2 presents the average number of cases per month by identified allergic trigger using the combined King County and Seattle data. The average number of cases due to a medication and to food as an allergic trigger remained relatively stable throughout the year. We observed a seasonal variation in allergic reactions due to insect stings with the majority of cases falling between April and October, closely mirroring the warmer weather in the Pacific Northwest United States. This trend was mirrored by the environmental exposure category, which was largely made up of patients who had allergic symptoms shortly after walking through wooded areas or being exposed to freshly cut foliage.

There were two instances of cardiac arrest requiring EMS resuscitation following clearly documented severe anaphylactic shock, one patient with hymenoptera envenomation and another with a food allergy, both of whom were resuscitated in the field and survived to hospital admission. Both patients received their first dose of EMT epinephrine while they were already in extremis.

Most EMTs in King County operate in pairs on ambulances or as part of a fire department BLS unit, typically an engine company that may have between 2 and 4 EMTs on the apparatus. Given the 422 cases of administration identified through the study period and the 3500 EMTs trained, approximately 1300 individual EMTs were involved in treating anaphylactic patients during this time. Individual EMTs were not tracked as to the number of events. Due to the mechanism of de-identifying the charts and the mixture of paper and electronic charts, we did not track individual EMT administration.

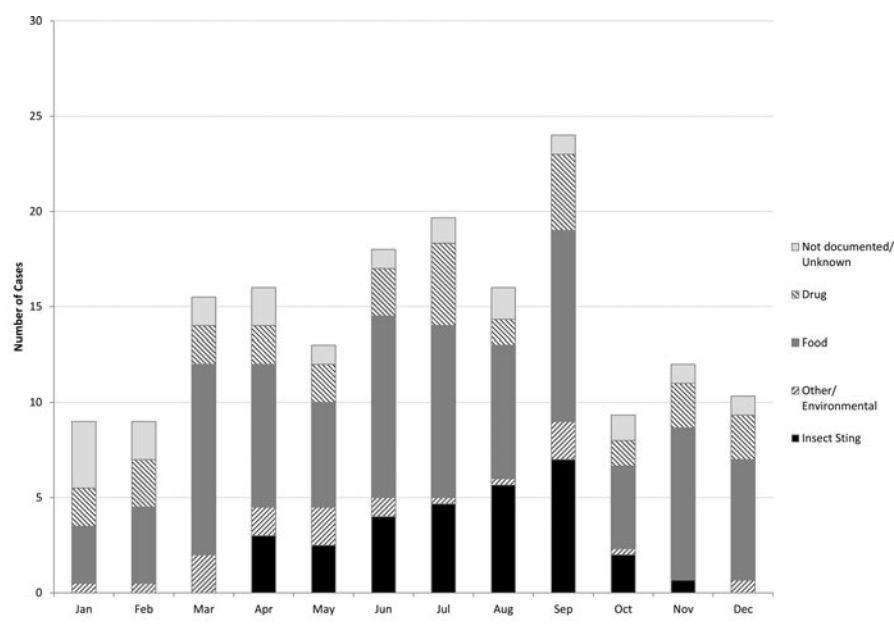


FIGURE 2. Distribution of triggers by month.

During the study period incident reports transitioned from a combination of paper reports and on line entries to a new electronic medical record. It was thus not possible to link every EMT report of epinephrine administration to the paramedic incident report, although we were able to link over 90% of the cases. We did not find any episodes in which the paramedic report contradicted the EMTs decision to administer epinephrine.

DISCUSSION

In this large cohort of patients treated with IM epinephrine by EMTs for serious allergy and/or anaphylaxis, we observed that the EMT typically identified patients meeting the criteria and administered epinephrine per standing “Check and Inject” protocol. Among the 10.7% of patients who did not meet protocol criteria, most without a clear allergic trigger, epinephrine administration was deemed clinically indicated in approximately 81.8% of cases based on physician review. Among the 4.8% of patients for whom physician review found epinephrine was not indicated, there were no documented adverse outcomes related to epinephrine administration based on review of prehospital care. Taken together, the results suggest that an EMT working as part of a BLS crew can effectively administer IM epinephrine to a clinically-appropriate, at-risk group based on a standing protocol that uses manual aspiration and delivery approach of “Check and Inject.”

In this large contemporary cohort, EMTs typically selected clinically appropriate patients for treatment of severe allergy and anaphylaxis consistent with a small

historical investigation from the study community (9). In this earlier study, EMTs could follow an anaphylaxis protocol using a much more restrictive definition of anaphylaxis requiring the presence of respiratory distress and/or shock with a suspected trigger. The previous protocol did not include hives or oral swelling as potential criteria. The current results, however, were also accomplished using a manual EMT approach to epinephrine delivery that was directed by a structured standing protocol. Based on this approach, 36 (8.8%) patients received EMT epinephrine who did not have a clear allergic trigger documented but had symptoms of a severe allergic reaction or frank anaphylaxis upon physician review. We discovered that a clear allergic trigger is not always readily apparent at the scene or captured in the EMS documentation.

The results also indicate that EMS should be prepared to treat serious allergy and/or anaphylaxis in patients across all ages as approximately 20% of patients were younger than 14 years of age and 10% were older than 65 years. Using the protocol, most patients had more than one sign or symptom, with about half having hives, respiratory symptoms, or local swelling, while only a minority had frank hypotension. The fact that only a minority manifested hypotension is consistent with the most recent specialty guidelines which support early administration in an effort to prevent anaphylactic shock. A majority of patients (92.5%) had at least one abnormal vital sign prior to epinephrine administration.

The “Check and Inject” protocol was designed to balance inclusivity with prudence in patient selection. All 12 patients who received EMT IM epinephrine consistent with the “Check and Inject” protocol but were

categorized as “epinephrine not-indicated” on physician review had one isolated allergic symptom. There were 8 other patients that neither satisfied protocol criteria nor had epinephrine indicated on physician review. In the 20 total patients in which epinephrine was not indicated on physician review, we did not observe adverse consequences of epinephrine administration documented in the EMS records or EMT interview, including no new hemodynamic instability or new symptoms such as chest pain or palpitations. Given these findings, we feel that the protocol achieves an appropriate balance. Additional evaluation of the “Check and Inject” protocol should consider potential to refine selection based on the lack of trigger or the requirement for more than a single sign or symptom.

In the King County EMS system, we conservatively estimate a cost-savings of roughly \$335,000 annually in transitioning to the “Check and Inject” program from EAI (17). In response to financial pressure, 13 states in the United States have begun programs to implement similar training (18).

There were several limitations to our analysis. We were unable to obtain follow-up information and patient outcomes from hospital records. We have no mechanism to detect potential cases of anaphylaxis or severe allergic reactions that weren’t considered by EMS (i.e., potential “misses”). Complications or adverse reactions to EMT epinephrine that were not observed in the prehospital setting may have been missed if they presented later during hospital evaluation. The physician assessment relied on the written documentation in the medical report forms and did not independently verify the history or physical exam findings. A review of the paramedic reports did not reveal information that would indicate that EMT epinephrine was inappropriate, though the paramedic report would potentially be biased by EMT presentation of the case and the goal to work collectively as a team to provide consistent care.

The study was a programmatic evaluation and not a randomized trial so we cannot be certain that there was a satisfactory safety profile compared to EAI use. However, the high level of protocol compliance and physician agreement in conjunction with the favorable safety assessment would support the “Check and Inject” program as a reasonable and responsible strategy.

The study was conducted in a mature EMS system in a metropolitan County that undertook initial and ongoing specific training and monitoring. We cannot be certain that the results are generalizable to other systems or circumstances.

CONCLUSION

We found that EMTs in King County, Washington successfully aspirated epinephrine from a vial and administered it intramuscularly for severe allergic reactions

and anaphylaxis in a manner that typically agreed with physician review and without any overt identified safety issues. The findings support the potential for effective manual aspiration and IM administration of epinephrine by EMTs in a mature system that undertakes ongoing training and quality review.

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References

1. Montanaro A, Bardana EJ Jr. The mechanisms, causes, and treatment of anaphylaxis. *J Investig Allergol Clin Immunol*. 2002 Jan 2;12(1):2–11. doi:10.1001/archinte.161.1.15.
2. Neugut AI, Ghatak AT, Miller RL. Anaphylaxis in the United States: an investigation into its epidemiology. *Arch Intern Med*. 2001 Jan 1;161(1):15–21. doi:10.1016/j.jaip.2016.08.013.
3. 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 Feb 28;5(1):171–75. doi:10.1016/j.jaci.2016.04.029.
4. Lee S, Hess EP, Lohse C, Gilani W, Chamberlain AM, Campbell RL. Trends, characteristics, and incidence of anaphylaxis in 2001–2010: a population-based study. *J Allergy Clin Immunol*. 2017 Jan 31;139(1):182–88.
5. Kemp SF, Lockey RF, Simons FE. Epinephrine: the drug of choice for anaphylaxis—a statement of the world allergy organization. *World Allergy Organ J*. 2008 Jul 15;1(2):S18–26. doi:10.1111/all.12318.
6. Dhami S, Panesar SS, Roberts G, Muraro A, Worm M, Bilò MD, et al. Management of anaphylaxis: a systematic review. *Allergy*. 2014 Feb 1;69(2):168–75. doi:10.3109/10903127.2011.598618.
7. National Association of EMS Physicians. The use of epinephrine for out-of-hospital treatment of anaphylaxis. *Prehosp Emerg Care*. 2011 Aug 30;15(4):544. doi:10.1016/j.jemermed.2004.04.018.
8. Kane KE, Cone DC. Anaphylaxis in the prehospital setting. *J Emerg Med*. 2004 Nov 30;27(4):371–77. doi:10.1080/312704000802.
9. Rea TD, Edwards C, Murray JA, Cloyd DJ, Eisenberg MS. Epinephrine use by Emergency Medical Technicians for presumed anaphylaxis. *Prehosp Emerg Care*. 2004 Jan 1;8(4):405–10. doi:10.5811/westjem.2016.8.30505.
10. Campbell RL, Bellolio FF, Motosue MS, Sunga KL, Lohse CM, Rudis MI. Autoinjectors preferred for intramuscular epinephrine in anaphylaxis and allergic reactions. *West J Emerg Med*. 2016 Nov;17(6):775–82. doi:10.1001/jama.2016.14505.
11. Epinephrine auto-Injectors for anaphylaxis. *JAMA*. 2017 Jan;317(3):313. doi:10.1016/S0140-6736(16)31708-1.
12. Rubin R. EpiPen price hike comes under scrutiny. *Lancet*. 2016 Sep 24;388(10051):1266. doi:10.1016/S1081-1206(10)60332-8.
13. Simons FE, Lieberman PL, Read EJ, Edwards ES. Hazards of unintentional injection of epinephrine from autoinjectors: a systematic review. *Ann Allergy Asthma Immunol*. 2009 Apr 30;102(4):282–87. doi:10.1016/j.annemergmed.2015.07.011.
14. Brown JC, Tuuri RE, Akhter S, Guerra LD, Goodman IS, Myers SR, Nozicka C, Manzi S, Long K, Turner T, Connors GP. Lacerations and embedded needles caused by epinephrine autoinjector use in children. *Ann Emerg Med*. 2016 Mar 31;67(3):307–15.
15. US Bureau of the Census. Census.gov [Internet]. U.S. Bureau of the Census. 2017 [cited 2 February 2017]. Available

from: <http://www.census.gov> doi:10.1016/j.annemergmed.2006.01.018.

16. Sampson HA, Muñoz-Furlong A, Campbell RL, Adkinson NF, Bock SA, Branum A, et al. Second symposium on the definition and management of anaphylaxis: Summary report—second National Institute of Allergy and Infectious Disease/Food Allergy and Anaphylaxis Network symposium. *Ann Emerg Med*. 2006 Apr 6;47(4):373–80.
17. Husein S, Nolan J, Latimer A, Eisenberg M. King County (Wash.) EMS saves \$334,000 annually by switching to IM delivery of epi by EMTs. *JEMS*. 2017 Jun 1;42(6) 26–30. doi:10.1080/10903127.2017.1294224.
18. Brasted ID, Dailey MW. Basic life support access to injectable epinephrine across the United States. *Prehosp Emerg Care*. 2017 Jul-Aug;21(4) 442–47.