



## Original Contribution

# Pediatric emergency medical services in privately insured patients: A 10-year national claims analysis☆



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## ABSTRACT

**Objective:** To characterize pediatric Emergency Medicine Service (EMS) transports to the Emergency Department (ED) using a national claims database.

**Methods:** We included children, 18 years and younger, transported by EMS to an ED, from 2007 to 2016 in the OptumLabs Data Warehouse. ICD-9 and ICD-10 diagnosis codes were used to categorize disease system involvement. Interventions performed were extracted using procedure codes. ED visit severity was measured by the Minnesota Algorithm.

**Results:** Over a 10-year period, 239,243 children were transported. Trauma was the most frequent diagnosis category for transport for children  $\geq 5$  years of age, 35.1% (age 6–13) and 32.7% (age 14–18). The most common diagnosis category in children  $< 6$  years of age was neurologic (29.3%), followed by respiratory (23.1%). Over 10 years, transports for mental disorders represented 15.3% in children age 14 to 18, and had the greatest absolute increase (rate difference + 10.4 per 10,000) across all diagnoses categories. Neurologic transports also significantly increased in children age 14 to 18 (rate difference + 6.9 per 10,000). Trauma rates decreased across all age groups and had its greatest reduction among children age 14 to 18 (rate difference – 6.8 per 10,000). Across all age groups, an intervention was performed in 15.6%. Most children (83.3%) were deemed to have ED care needed type of visit, and 15.8% of the transports resulted in a hospital admission.

**Conclusion:** Trauma is the most frequent diagnosis for transport in children older than 5 years of age. Mental health and neurologic transports have markedly increased, while trauma transports have decreased. Most children arriving by ambulance were classified as requiring ED level of care. These changes might have significant implication for EMS personnel and policy makers.

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**Abbreviations:** ALS, Advanced Life Support; BLS, Basic Life Support; BVM, bag-valve-mask; CI, confidence intervals; ED, Emergency Department; EMS, Emergency Medical Services; HCPCS/CPT, Healthcare Common Procedure Coding System; IV, intravenous; NEMSIS, National EMS Information System; NHAMCS, National Hospital Ambulatory Medical Care Survey; OLDW, OptumLabs Data Warehouse; PECARN, Pediatric Emergency Care Research Network; RECORD, Reporting of Studies Conducted Using Observational Routinely-Collected Health Data.

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## 1. Introduction

Emergency Medical Services (EMS) provide the vital first assessment and intervention for diverse medical issues. Children make up approximately 5 to 10% of all EMS transports [1,2]. EMS transported over one million children to Emergency Departments (ED) across the United States in 2014 [3]. Prehospital providers must be prepared to administer services for every age, size and complexity of patient. Given the wide scope of practice of these providers, researchers must identify critical patient populations and procedures so that they can be targeted in education and planning. While many skills transfer from adult to pediatric patients, others do not given the unique anatomical and physiologic nature of children.

Nationally developed EMS information systems and research networks have not been able to provide comprehensive data on EMS

transports. [4,5] Alternatively, medical claims, which have a streamlined and established data infrastructure, can be used to analyze the epidemiology and time trends. [6,7] Claims data consists of specific pre-established criteria that describe specific diagnoses, procedures and medications. Since provider based coding is necessary for reimbursement, claims data provide a standardized source of patient information.

The objectives of this study are 1) to describe age-based diagnoses and procedures performed by EMS in a privately insured pediatric population across the United States, 2) analyze diagnosis trends for EMS transports from 2007 to 2016, and (3) describe the ED visit severity of children arriving via EMS using the Minnesota Algorithm [8], which is a predictor of hospitalizations and death in other populations.

## 2. Methods

This report adheres to recommendations made in the RECORD (Reporting of Studies Conducted Using Observational Routinely-Collected Health Data) statement [9].

### 2.1. Study design and data source

This was an observational study of privately insured patients age 18 and younger who used EMS from January 1, 2007, through December 31, 2016. We used administrative claims data from the OptumLabs Data Warehouse (OLDW): a database composed of privately insured and Medicare beneficiaries [10]. Data available includes enrollee characteristics (sex, age, race/ethnicity, household income), diagnosis codes, Healthcare Common Procedure Coding System (HCPCS/CPT) procedure codes, site of service codes, and provider specialty codes [11]. All claims for EMS transport provided to children with medical coverage during this 10-year period were considered. This study involved analysis of preexisting, de-identified data and was determined to be exempt from review by the Mayo Clinic Institutional Review Board.

### 2.2. Study population

We identified all EMS transports from non-hospital facilities to the ED (including runs from scene, home, physician offices and other facilities) between January 1, 2007 and December 31, 2016, by beneficiaries of age  $\leq 18$ . Transportation between hospitals was excluded. We categorized children by their educational stage as followed: age 0 to 5 (pre-school), 6 to 13 (elementary and middle-school) and 14 to 18 (high-school).

### 2.3. Main variables and outcomes measures

Patient characteristics included were age, sex, race/ethnicity and household income. The unit of analysis is a person-day on which ambulance services were billed. A person may have experienced multiple ambulance rides on a single date, but these separate rides cannot always be separately identified in claims data because of the lack of time stamps, so the characteristics of all services with a hospital destination on a single day are summarized. EMS data includes the primary diagnosis for the EMS service and interventions issued by the EMS provider. We selected the primary diagnosis for each person-day of service from the EMS claim with the highest level of service (ALS, then BLS). Diagnoses were then grouped by ICD-9 or ICD-10 diagnosis codes using a classification system based on Clinical Classifications Software categories [12] as follows: trauma/environmental (e.g. trauma, poisoning, external injuries), mental disorders, allergy, respiratory, neurologic, gastrointestinal/genitourinary, cardiovascular, infection, others (endocrine/metabolic, hematology/blood disorders, ear/nose/throat, cancer/neoplasm, congenital, obstetrics, dermatology, rheumatology, other), and unknown reasons. Interventions performed by EMS include those related to either Advanced Life Support (ALS) or Basic Life Support (BLS), using the CPT codes specific to ambulance services. The

proportion of person-days of service with each intervention, including ALS services, BLS services, defibrillation, intubation, intravenous (IV) medications and oxygen, was reported.

The ED severity of children arriving via EMS to the ED was defined using the Minnesota Algorithm [8], which has been shown to be a strong predictor of hospitalizations and death. The Minnesota Algorithm is used specifically for administrative claim data and was validated using a nationally representative sample of Medicare data [8]. Using this algorithm, we categorized the ED visits as ED care needed vs primary care treatable [8], and reported the number of patients who were admitted to the hospital on the same day as the ambulance ride.

### 2.4. Statistical analysis

Patient characteristics were described using median (25th, 75th percentiles) or proportions (95% confidence intervals; CI), as appropriate. Annual rates of ambulance transport were calculated per 10,000 covered children. The proportion of ambulance rides with each reported type of intervention was also shown; each ride could have more than one intervention/service. Stata/MP (version 15.1; StataCorp, College Station, TX) was used for all analyses. To protect patient confidentiality, we only report results that include at least 11 person-days of service.

## 3. Results

### 3.1. Patient and transport characteristics

EMS transported 239,243 insured children age  $\leq 18$  years from 2007 to 2016. Age, sex, race/ethnicity and income are displayed in Table 1. The median age was 13 years (quartiles 5 to 16 years), females accounted for 46.3% of the sample. White race accounted for 67.7% of the sample, followed by Black (11.4%) and Hispanic (10.7%). More than two-fifths (41.1%) of the children in the sample came from households with income under \$100,000. Transport from a residence was most common for children less-than 6 years of age at 54.3%. Children 6 years and older were transported most frequently from the scene, totaling greater than 60% of cases (see Table 2).

### 3.2. EMS diagnosis categories

The most common EMS diagnosis category in children age 0 to 5 was neurologic (29.3%), followed by respiratory (23.1%) and trauma/environmental (21.8%). In children age 6 to 13, trauma/environmental was the most common category (35.1%), followed by neurologic (16.6%) and respiratory (11.5%). In children age 14 to 18, trauma/environmental was the leading category (32.7%), followed by mental disorders (15.3%) and neurologic (14.6%).

### 3.3. EMS diagnosis trends

The trends in primary ambulance diagnosis categories over the ten years of the study period are reported in Table 3 and Fig. 1. Transports for mental health related diagnoses for children age 14 to 18 increased by +10.4 per 10,000 person-years (95%CI 8.9 to 12), from 18.1 per 10,000 enrollees in 2007 to 28.6 per 10,000 enrollees in 2016, with a relative increase of 57.6% over the study period. (Fig. 2) Neurologic related transports increased in children age 14 to 18 (rate difference + 6.9 per 10,000 person-years [95% CI 5.4 to 8.5]). The rate of trauma/environmental diagnosis category decreased from 2007 to 2016 across all age groups. Trauma/environmental had its greatest absolute reduction among children age 14 to 18 (rate difference: -6.8 per 10,000 [95% CI -9 to -4.7]). Overall, the rates of allergy related diagnoses were low among EMS transports in the pediatric population (2.6% across the entire sample), but demonstrated the greatest relative change over the study period when compared to other categories (Supplementary

**Table 1**  
Characteristics of privately insured pediatric EMS services (2007–2016).

| Enrollee/beneficiary characteristic    | Age 0–5 (n = 65,172)* |             | Age 6–13 (n = 60,469)* |             | Age 14–18 (n = 113,602)* |             | Total all age (n = 239,243)* |             |
|--|-----------------------|-------------|------------------------|-------------|--------------------------|-------------|------------------------------|-------------|
|  | Value#                | (95% CI)    | Value#                 | (95% CI)    | Value#                   | (95% CI)    | Value#                       | (95% CI)    |
| Age, median (IQR)                      | 2                     | (1–5)       | 10                     | (8, 12)     | 17                       | (15, 18)    | 13                           | (5–16)      |
| Sex, %                                 |                       |             |                        |             |                          |             |                              |             |
| Female                                 | 42.6                  | (42.2–43)   | 41.3                   | (40.9–41.7) | 51.1                     | (50.8–51.4) | 46.3                         | (46.1–46.5) |
| Race/ethnicity, %                      |                       |             |                        |             |                          |             |                              |             |
| White                                  | 63.2                  | (62.8–63.5) | 67.7                   | (67.3–68.1) | 70.4                     | (70.2–70.7) | 67.7                         | (67.6–67.9) |
| Black                                  | 10.1                  | (9.8–10.3)  | 12                     | (11.7–12.2) | 11.8                     | (11.6–12)   | 11.4                         | (11.2–11.5) |
| Hispanic                               | 11.3                  | (11.1–11.6) | 10.9                   | (10.7–11.2) | 10.2                     | (10–10.4)   | 10.7                         | (10.6–10.8) |
| Asian                                  | 6.7                   | (6.5–6.9)   | 3.9                    | (3.8–4.1)   | 2.5                      | (2.4–2.6)   | 4.0                          | (4.0–4.1)   |
| Unknown                                | 8.7                   | (8.4–8.9)   | 5.5                    | (5.3–5.7)   | 5.1                      | (5–5.2)     | 6.2                          | (6.1–6.3)   |
| Household income, %                    |                       |             |                        |             |                          |             |                              |             |
| \$40,000 or less                       | 8.1                   | (7.9–8.3)   | 8.9                    | (8.6–9.1)   | 11.3                     | (11.1–11.4) | 9.8                          | (9.7–9.9)   |
| \$40,000–\$49,999                      | 4.8                   | (4.7–5)     | 4.8                    | (4.6–4.9)   | 5.3                      | (5.2–5.4)   | 5.0                          | (4.9–5.1)   |
| \$50,000–\$59,999                      | 5.2                   | (5.1–5.4)   | 5.2                    | (5–5.3)     | 5.7                      | (5.5–5.8)   | 5.4                          | (5.3–5.5)   |
| \$60,000–\$74,999                      | 8.4                   | (8.2–8.7)   | 7.8                    | (7.5–8)     | 8.2                      | (8–8.3)     | 8.1                          | (8.0–8.3)   |
| \$75,000–\$99,999                      | 13.5                  | (13.2–13.7) | 12.2                   | (11.9–12.4) | 12.7                     | (12.5–12.9) | 12.8                         | (12.6–12.9) |
| \$100,000 or more                      | 38.3                  | (37.9–38.7) | 41.4                   | (41–41.8)   | 37.2                     | (36.9–37.4) | 38.5                         | (38.3–38.7) |
| Unknown                                | 21.6                  | (21.3–22)   | 19.9                   | (19.6–20.2) | 19.8                     | (19.5–20)   | 20.3                         | (20.2–20.5) |
| Identified ED visit on the same day, % | 90.2                  | (89.9–90.4) | 92.5                   | (92.3–92.7) | 90.3                     | (90.1–90.4) | 90.8                         | (90.7–90.9) |

\* This represents total number of ambulance rides/service dates, not unique patients. Percentages are shown per person-date of service.

# Percentages may not sum to 100 due to rounding.

Data). Across all age groups, transports for allergy related diagnoses increased from 1.67 per 10,000 enrollees in 2007 to 3.27 per 10,000 enrollees in 2016.

### 3.4. EMS interventions

The majority of children were transport by ALS (57.9%). At least one of the billable interventions (defibrillation, intubation, oxygen administration, or IV medications) was performed in 15.6% of children receiving ALS transport. Oxygen administration was performed most frequently

in the youngest age group at 10.8% of all transports (ALS and BLS) compared to 7.7% in the oldest age group. (Table 2) Across all age groups and diagnoses, endotracheal intubation (ETI) was performed in 0.2% of ALS transports. The cardiovascular diagnosis category had the highest rate of ETI at 2.1% in the 0 to 5 year olds, 0.5% in children 6 to 13 years of age, and 0.6% in the 14 to 18 age group. The rate of field ETI decreased 0.36% over the ten-year period from 0.57% in 2007 to 0.21% in 2016. Across all age groups, IV medications were administered in 4.2%. Administration of an IV medication during transport increased across age groups, with 1.7% of children age 0 to 5 receiving IV medications

**Table 2**  
Characteristics of ambulance rides (2007–2016).

|  | Age 0–5 (n = 65,172)* |             | Age 6–13 (n = 60,469)* |             | Age 14–18 (n = 113,602)* |             | Total all ages (n = 239,243)* |             |
|--|-----------------------|-------------|------------------------|-------------|--------------------------|-------------|-------------------------------|-------------|
|  | Value#                | (95% CI)    | Value#                 | (95% CI)    | Value#                   | (95% CI)    | Value#                        | (95% CI)    |
| Ambulance origin, %  |                       |             |                        |             |                          |             |                               |             |
| Scene  | 34                    | (33.6–34.4) | 61.5                   | (61.1–61.9) | 66.9                     | (66.7–67.2) | 56.6                          | (56.4–56.8) |
| Residence  | 54.3                  | (53.9–54.7) | 31.4                   | (31.1–31.8) | 28.9                     | (28.6–29.2) | 36.5                          | (36.3–36.6) |
| Physician office   | 10                    | (9.7–10.2)  | 5.6                    | (5.5–5.8)   | 2.6                      | (2.5–2.7)   | 5.4                           | (5.3–5.5)   |
| Other origin   | 1.7                   | (1.6–1.8)   | 1.5                    | (1.4–1.6)   | 1.6                      | (1.5–1.7)   | 1.6                           | (1.5–1.6)   |
| Primary ambulance diagnosis†, %                                |                       |             |                        |             |                          |             |                               |             |
| Trauma/Environmental   | 21.8                  | (21.4–22.1) | 35.1                   | (34.7–35.5) | 32.7                     | (32.4–32.9) | 30.3                          | (30.1–30.5) |
| Respiratory  | 23.1                  | (22.8–23.4) | 11.5                   | (11.3–11.8) | 5.3                      | (5.2–5.5)   | 11.7                          | (11.6–11.9) |
| Neurologic   | 29.3                  | (29–29.7)   | 16.6                   | (16.3–16.9) | 14.6                     | (14.4–14.8) | 19.1                          | (19.0–19.3) |
| Mental Disorders   | 1.2                   | (1.2–1.3)   | 5.8                    | (5.6–6)     | 15.3                     | (15.1–15.5) | 9.1                           | (9.0–9.2)   |
| Allergy  | 3.7                   | (3.6–3.8)   | 3                      | (2.9–3.1)   | 1.7                      | (1.6–1.8)   | 2.6                           | (2.5–2.6)   |
| Cardiovascular   | 3.4                   | (3.3–3.5)   | 6.9                    | (6.7–7.1)   | 9.3                      | (9.1–9.5)   | 7.1                           | (7.0–7.2)   |
| GI/GU  | 3.9                   | (3.8–4)     | 5.5                    | (5.3–5.6)   | 6.4                      | (6.3–6.6)   | 5.5                           | (5.4–5.6)   |
| Infection  | 6                     | (5.8–6.2)   | 1.7                    | (1.6–1.8)   | 0.6                      | (0.5–0.6)   | 2.3                           | (2.3–2.4)   |
| Other/unknown reason   | 7.6                   | (7.4–7.8)   | 13.9                   | (13.6–14.2) | 14.1                     | (13.9–14.3) | 12.3                          | (12.1–12.4) |
| Ambulance intervention, % of ambulance rides with each service |                       |             |                        |             |                          |             |                               |             |
| ALS service  | 56                    | (55.6–56.3) | 55.1                   | (54.7–55.5) | 60.5                     | (60.2–60.8) | 57.9                          | (57.7–58.1) |
| BLS service  | 46.1                  | (45.7–46.5) | 47.1                   | (46.7–47.5) | 42                       | (41.7–42.3) | 44.4                          | (44.2–44.6) |
| Defibrillation   | 0.6                   | (0.6–0.7)   | 0.7                    | (0.6–0.8)   | 0.9                      | (0.8–0.9)   | 0.8                           | (0.7–0.8)   |
| Intubation‡  | 0.2                   | (0.2–0.2)   | 0.1                    | (0.1–0.1)   | 0.2                      | (0.1–0.2)   | 0.2                           | (0.1–0.2)   |
| IV medications‡  | 1.7                   | (1.6–1.8)   | 3.5                    | (3.4–3.7)   | 6.1                      | (5.9–6.2)   | 4.2                           | (4.1–4.3)   |
| Oxygen   | 10.8                  | (10.6–11.1) | 7.7                    | (7.5–7.9)   | 7.7                      | (7.6–7.9)   | 8.6                           | (8.5–8.7)   |

\* This represents total number of ambulance rides/service dates and not unique patients. Percentages are shown per person-date of service.

† Primary ambulance diagnoses were identified by the ICD codes that were linked to the ambulance claim and were categorized as shown in the table.

‡ Intervention only available with ALS.

# Percentages may not sum to 100 due to rounding.

**Table 3**

Absolute rate differences in primary ambulance diagnosis categories from 2007 to 2016, per 10,000 person-years.

|                      | Age 0–5 |      |                 |                | Age 6–13 |      |                 |                | Age 14–18 |      |                 |                |
|----------------------|---------|------|-----------------|----------------|----------|------|-----------------|----------------|-----------|------|-----------------|----------------|
|                      | 2007    | 2016 | Rate difference | 95% CI         | 2007     | 2016 | Rate difference | 95% CI         | 2007      | 2016 | Rate difference | 95% CI         |
| Trauma/Environmental | 21.3    | 18.4 | −2.9            | (−4.4 to −1.5) | 19.1     | 16.5 | −2.5            | (−3.6 to −1.4) | 50.2      | 43.4 | −6.8            | (−9 to −4.7)   |
| Respiratory          | 20.5    | 22.9 | +2.4            | (0.8 to 3.9)   | 6        | 5.6  | −0.4            | (−1 to 0.3)    | 9.4       | 7.1  | −2.3            | (−3.3 to −1.4) |
| Neurologic           | 27.5    | 29.4 | +1.9            | (0.2–3.7)      | 7.9      | 9.7  | +1.8            | (1 to 2.5)     | 19.9      | 26.8 | +6.9            | (5.4 to 8.5)   |
| Mental Disorders     | 1.3     | 0.2  | −1.1            | (−1.4 to −0.8) | 2.4      | 3.2  | +0.9            | (0.4 to 1.3)   | 18.1      | 28.6 | +10.4           | (8.9 to 12)    |
| Allergy              | 2.8     | 4.9  | +2.1            | (1.4 to 2.7)   | 0.9      | 2.3  | +1.4            | (1 to 1.7)     | 1.7       | 3.3  | +1.6            | (1.1 to 2.1)   |
| Cardiovascular       | 3       | 4.4  | +1.4            | (0.8 to 2.1)   | 3.5      | 4.2  | +0.7            | (0.2 to 1.2)   | 13.9      | 15.4 | +1.5            | (0.3 to 2.7)   |
| GI/GU                | 4.1     | 3.5  | −0.5            | (−1.2 to 0.1)  | 2.9      | 2.8  | −0.2            | (−0.6 to 0.3)  | 9.9       | 9.2  | −0.7            | (−1.7 to 0.3)  |
| Infection            | 5.8     | 6.4  | +0.7            | (−0.2 to 1.5)  | 1        | 0.9  | +0.0            | (−0.3 to 0.2)  | 0.8       | 0.6  | −0.2            | (−0.5 to 0.1)  |
| Other/unknown reason | 7.5     | 7.8  | +0.4            | (−0.5 to 1.3)  | 8.9      | 7.7  | −1.2            | (−1.9 to −0.4) | 24.8      | 22.7 | −2.1            | (−3.6 to −0.5) |

compared to 6.1% of children age 14 to 18. The highest rate of IV medication administration was seen in the cardiovascular diagnosis category for the youngest age group (5.5%), neurologic in the middle age group (7.9%), and trauma/environmental in the oldest age group (11.6%). Defibrillation occurred in 0.8% of pediatric transports. BLS performed defibrillation in 0.11% of transports. ALS performed defibrillation in 1.3% of transports. The highest rate of defibrillation was seen in the oldest age group, 14 to 18 years, at 0.9%.

#### ED visit severity.

Across all age groups, 90.8% ambulance rides had an ED visit identified on the same day. Of these ED visits, 17.2% (age 0 to 5), 13.5% (age 6 to 13) and 16.2% (age 14 to 18) resulted in an inpatient admission from the ED. The EMS diagnoses for children who were admitted as inpatients are shown in the Supplementary Data. The Minnesota algorithm classified the greatest rate of ED care needed visits among children in the oldest age group (87.9%), while children age 0 to 5 had 77.4% of ED visits classified as ED care needed, as compared to primary care treatable (Table 4).

## 4. Discussion

In this nationally representative cohort of privately insured children, we found that in patients age 0 to 5 the most common reason for transport to the ED was neurologic, while in children older than 5, trauma/environmental was the most common category. From 2007 to 2016, mental disorders and neurologic diagnoses demonstrated the greatest absolute increase in rate of EMS transports over time. Trauma significantly decreased across all age groups and had its greatest rate reduction among children age 14 to 18, however continues to be the leading overall cause for transport. Most children were transported by ALS, as compared to BLS. Interventions by EMS providers were infrequent. Most children's visits were categorized as ED care needed, with an overall admission rate of 15.8%. This study provides the latest epidemiology and trends for pediatric EMS utilization in commercially insured children. By using claims data, we are able to capture more complete data for the included population that was possible using

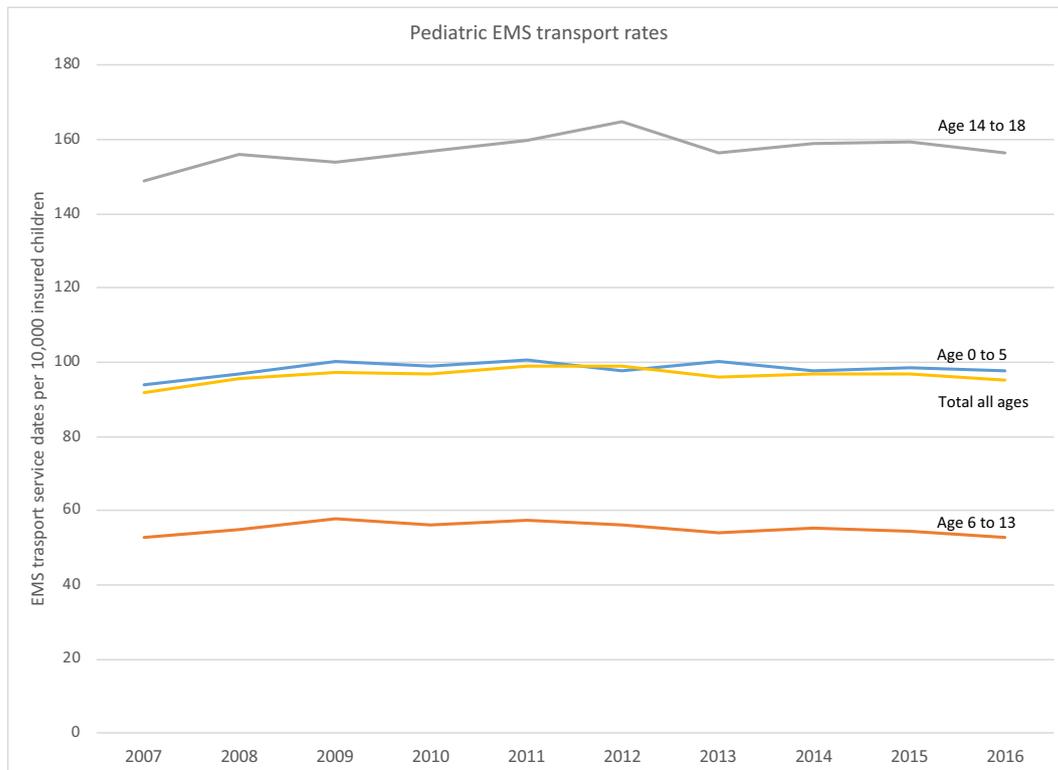


Fig. 1. Trends over time in pediatric EMS transports by age group.

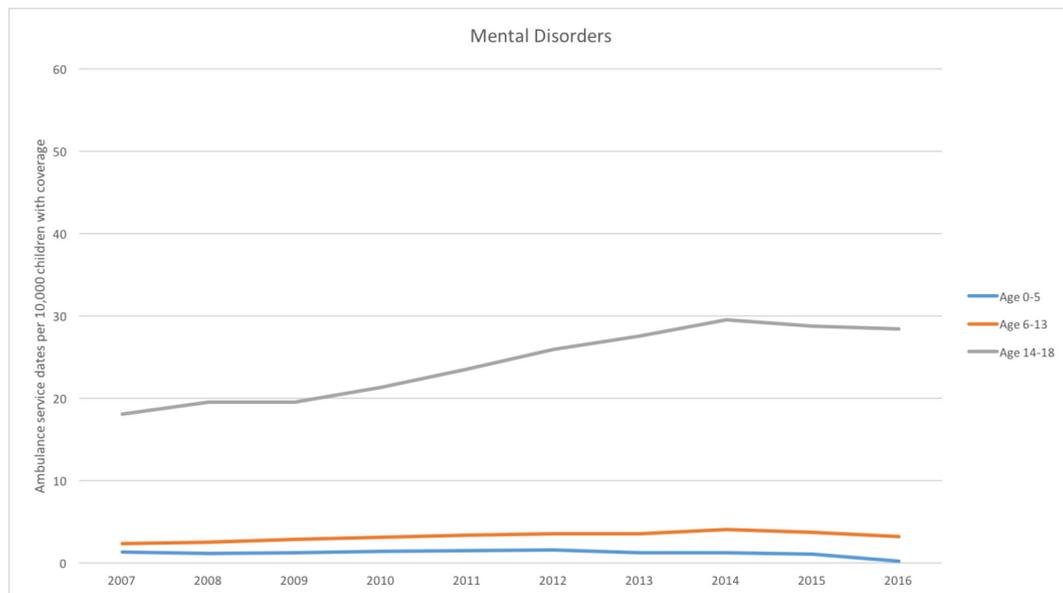


Fig. 2. Trends over time in pediatric EMS transports for mental health related diagnoses by age group.

either the National EMS Information System (NEMSIS) or the Pediatric Emergency Care Research Network (PECARN) [2,4].

Trauma is the leading diagnosis for transport of children older than 5 years of age, at over 30% of transports. The highest percentage was seen in children 6 to 13 years of age, at 35.1%. This peak of trauma EMS transports among school-aged children was also seen in the PECARN EMS study at 30.9% of children age 6 to 12 years [4], and in the Milwaukee NEMSIS study for children 10 to <15 years of age at 18.9% [1]. The increased rate of trauma in school-aged children is not surprising given their developmental stage and increased autonomy. The trend for trauma-related diagnoses decreased over the past 10 years, suggesting that prevention and educational interventions for school-aged children might have had an impact.

Mental disorders were the second leading diagnosis category in children age 14 to 18 years transported by EMS, at 15.3% of transports. In our study, from 2007 to 2016, transports related to mental disorders in children age 14 to 18 had the greatest absolute increase (rate difference + 10.4 per 10,000) across all diagnoses categories, with a relative increase of 57.6%. Other national studies confirmed the marked increase in mental disorders being evaluated in the ED. An analysis of the National Hospital Ambulatory Medical Care Survey (NHAMCS) data showed pediatric mental health visits for 6 to 20 year olds increased from 4.4% in 2001 to 7.2% in 2011 of ED visits [14]. This rise in EMS and ED utilization for mental disorders likely reflects the difficulty children have accessing mental health care across the United States [14]. EMS and ED providers will need training and tools to help children and families manage mental health crises in the safest way.

Although allergy-related diagnoses made up a small proportion of EMS transports with less than 3%, they accounted for the greatest relative increase over time among all of the age groups. The allergic disease

category includes the spectrum of allergy issues, and may reflect an increase in anaphylaxis. A recent study of ED anaphylaxis visits from 2005 to 2014 demonstrated a 130% increase in ED anaphylaxis visits among children age 0 to 4 years, and a 212% increase among children and adolescents age 5 to 17 years [6]. Our study found 2.6% of EMS transports had a primary diagnosis of an allergic issue; this is similar to a recent study performed in Australia that found 3.2% of children had an allergic or anaphylaxis diagnosis by EMS [15]. When looking at prehospital administration of intramuscular (IM) epinephrine, estimates are that at 32% of children with anaphylaxis received epinephrine from EMS [16]. It was unknown in that study if epinephrine had been administered prior to EMS arrival. In the Australian EMS anaphylaxis study [15], 62% of patients had epinephrine administered prior to EMS arrival, and EMS administered epinephrine in 45% of children, 8% received epinephrine before and after EMS arrival. Given the increasing nature of allergic related diagnosis found, EMS providers need to be able to recognize anaphylaxis and administer epinephrine.

Our study revealed that 57.9% of children had ALS billed as the level of transport; this is nearly identical to the rate of pediatric ALS transport found in the NEMSIS pediatric study at 57.2% [2]. Although most transports were billed as ALS, few patients received ALS interventions, which is similar to previous studies [2].

Airway support is critical for children to prevent the cascade from respiratory arrest to cardiac arrest. In our cohort, we had an overall rate of 8.6% of children receiving oxygen, with the highest rate in the youngest children (10.8%). In other studies, the rate of pediatric BVM ventilation is estimated to around 0.1% to 0.4% [1,4,17]. This emphasizes having appropriately sized oxygen masks and facemasks for BVM ventilation and oxygen administration during transport. Endotracheal intubation was performed infrequently at 0.2% over all age groups. Our rate of ETI was

Table 4

Characteristics of ED visits, if one was found.

|                                  | Age 0–5 (n = 58,760) |             | Age 6–13 (n = 55,952) |             | Age 14–18 (n = 102,549) |             | Total all ages (n = 217,261) |             |
|----------------------------------|----------------------|-------------|-----------------------|-------------|-------------------------|-------------|------------------------------|-------------|
|                                  | Value                | (95% CI)    | Value                 | (95% CI)    | Value                   | (95% CI)    | Value                        | (95% CI)    |
| Admitted as inpatient from ED, % | 17.2                 | (16.9–17.5) | 13.5                  | (13.2–13.7) | 16.2                    | (16–16.5)   | 15.8                         | (15.6–15.9) |
| ED visit severity, %             |                      |             |                       |             |                         |             |                              |             |
| ED care needed                   | 77.1                 | (76.8–77.5) | 81.2                  | (80.9–81.5) | 87.9                    | (87.7–88.1) | 83.3                         | (83.1–83.4) |
| Primary care treatable           | 22.6                 | (22.2–22.9) | 18.6                  | (18.3–19)   | 11.8                    | (11.6–12)   | 16.5                         | (16.3–16.6) |
| Unclassified                     | 0.3                  | (0.2–0.3)   | 0.2                   | (0.1–0.2)   | 0.2                     | (0.2–0.2)   | 0.2                          | (0.2–0.3)   |

similar to previous studies, which range from 0.2 to 0.3% [1,4,17]. Although not a frequent intervention, its complexity in the prehospital setting emphasizes the need for training and simulation, especially for the youngest children who have the greatest anatomical differences from adults.

The automated external defibrillator has revolutionized out-of-hospital cardiac arrest care for adults and children [18]. Though ventricular fibrillation has been thought to be rare in children, it is known to increase with age and is increasingly identified in the field. Ventricular fibrillation is estimated to contribute to 8 to 20% of pediatric cardiac arrests [19–21]. We found the overall rate of defibrillation pads utilized in children was 0.8% of pediatric transports, with the highest rate in the oldest age group.

The Minnesota Algorithm [8] was published in 2016 and describes whether the care provided during an ED visit suggests that the visit required an ED level of care. Using this algorithm, 16.5% of the identified ED visits were classified as primary care treatable. This may highlight recent findings that the decrease in access to primary care may play a role in the increased use of EDs among children regardless of their insurance status [22]. In our study, 15.8% of children were admitted as inpatients from the ED, which is lower than much older studies, where admission rates were up to 26% of patients transported by EMS [23,24]. We are not able to determine whether this reduction in admission rates reflects improvements in care provided in EDs, changes in the severity of illness among children transported by EMS, or differences in populations. However, patients admitted to the hospital under “observation” status, even if placed in regular hospital beds, are not considered “inpatients” for claims and billing data, and might also explain this lower admission rate [25,26].

The racial and ethnic distribution of our pediatric patient population is similar to the latest available NHAMCS report on ethnicity in the ED for children <15 years of age [3]. Of note, the NHAMCS includes the uninsured and people with government insurance, which may suggest our findings could be more broadly applicable outside of the privately insured population.

This study with 2007 to 2016 OptumLabs Data Warehouse data provides the most up-to-date analysis of diagnosis categories and procedures performed by EMS for children across the United States. Though other databases, particularly NEMESIS [2], have a far greater number of children, this study provides the most complete analysis of EMS diagnosis, procedures and trends. Another unique aspect of this study is that it specifically analyzes transports to the ED and links EMS data with emergency department data and their hospital admission.

#### 4.1. Limitations

Our analysis is limited to claims data among privately insured children. Claims data were fashioned to obtain reimbursement and were not designed for research purpose, and administrative claims data are susceptible to coding errors. Limited detail is available on specific procedures such as which medications were administered. Children with Medicaid or other government insurance or uninsured were not included, and privately insured children may differ from children with no insurance coverage. Currently, the CDC estimates that 54% of children <18 years of age are privately insured [13]. Thus, these findings may be considered representative of the majority of children in the United States. The Minnesota Algorithm was created and validated using claims data from Medicare patients, and its prediction of hospitalizations and death in the privately insured children population has not been separately validated. However, the algorithm uses the severity of the evaluation and management code billed by ED physicians, so it seems likely to be associated with the treating physician’s assessment of the potential severity of the visit, regardless of the age of the patient.

The number of defibrillations recorded was higher than expected, as our data is limited to billable supplies utilized during the encounter. Not all the defibrillator pads that were placed on patient’s chest were

utilized for defibrillation. Defibrillation pads are placed on every patient in cardiac arrest and they are billed for each instance, even if a defibrillation was not delivered.

#### 4.2. Conclusion

Trauma is the most common diagnosis for ambulance transport in children older than 5 years of age. Neurologic and respiratory diagnosis categories predominated in children 5 years and under. Neurologic and mental health transports have markedly increased, while trauma/environmental transports have decreased over the past 10 years. EMS interventions were infrequent across all age groups. Most children arriving to the ED by ambulance were classified as having visits requiring ED level of care (83.3%), with 15.8% being admitted as inpatients.

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#### Conflict of interest

None.

#### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ajem.2018.10.029>.

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