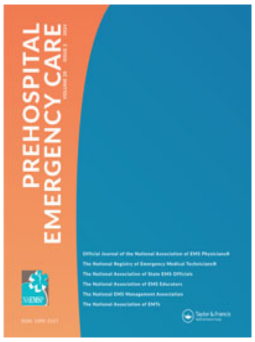

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Completeness of Pediatric Versus Adult Patient Assessment Documentation in the National Emergency Medical Services Information System

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ABSTRACT

Background: Pediatric prehospital encounters are proportionally low-frequency events. National pediatric readiness initiatives have targeted gaps in prehospital pediatric assessment and management. Regional studies suggest that pediatric vital signs are inconsistently obtained and documented. We aimed to assess national emergency medical services (EMS) data to evaluate completeness of assessment documentation for pediatric versus adult patients and to identify the documentation of condition-specific assessments.

Methods: We performed a retrospective cross-sectional analysis of EMS encounters from the National Emergency Medical Services Information System for 2019, including all 9-1-1 encounters resulting in transport. Our primary outcome was the proportion of encounters with complete vital signs (heart rate, respiratory rate, and systolic blood pressure) documented by pediatric age category relative to adult encounters. Pediatric patients were considered as those less than 18 years old. Our secondary outcome was condition-specific assessments for encounters with respiratory emergencies, cardiac complaints, and trauma. We performed multivariable logistic regression to calculate odds ratios (OR) and 95% confidence intervals (95% CI) for vital signs documentation by age after adjusting for sex, injury status, transport type (advanced vs basic life support), census region, urbanicity, organization nonprofit status, and organization type.

Results: Of 18,918,914 EMS encounters, 6.4% involved pediatric patients. Documentation of complete vital signs was lowest in those <1 month old (30.8%) and rose with increasing age (highest in adults; 91.8%). Relative to adults, the adjusted odds of documented complete vital signs in patients <1 month old was 0.03 (95% CI 0.03–0.03) and increased with age to 0.76 (95% CI 0.75–0.77) in those 12–17 years old. Among those patients with respiratory, cardiac, and traumatic complaints, children had lower proportions of documented pulse oximetry, monitor use, and pain scores, respectively, compared to adults.

Conclusion: Documentation of complete vital signs and condition-specific assessments occurs less frequently in children, especially in younger age groups, as compared to adults, which is a finding that exists across urbanicity, region, and level of response. These findings provide a benchmark for clinical care, quality improvement, and research in the prehospital setting.

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Introduction

Pediatric prehospital encounters are low-frequency events that require a refined set of assessment skills. Children comprise between 5.7% and 7.4% of emergency medical services (EMS) encounters, making it difficult for prehospital clinicians to achieve pediatric mastery by exposure alone (1, 2). Recognizing this challenge, stakeholders such as the American Academy of Pediatrics, American College of Emergency Physicians, Emergency Nurses Association, National Association of EMS Physicians, and National Association of Emergency Medical Technicians have placed growing emphasis on pediatric prehospital readiness to ensure that EMS clinicians can achieve and maintain pediatric clinical competence (3). At the core of this initiative is the recognition and treatment of the critically ill child through a comprehensive assessment (4–6), which includes documentation of respiratory rate, heart rate, blood pressure, pulse oximetry, weight, and pain level (7, 8). The National Association of State EMS Officials (NASEMSO) National Model EMS Clinical Guidelines, for example, recommend the acquisition of all vital signs for patients evaluated in the out-of-hospital setting (9). Previous efforts to evaluate vital signs documentation in children have been limited to regional data (10–16). These suggest that younger children, especially those under 2 years old, frequently do not have complete sets of vital signs recorded (10–16). To date, no large-scale evaluation of pediatric vital sign documentation has been performed using a national database.

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The use of large, high-resolution datasets serves as a critical component in the evaluation of health outcomes, particularly in pediatric investigations given the relative rarity of severe illness among children compared to adults. Many current prehospital research investigations are now moving beyond regional data and using larger national datasets such as the National EMS Information System (NEMSIS), a national EMS registry that is compiled from standardized patient care record data submitted prospectively (17). However, when using a large dataset, it is important to assess the completeness or missingness of data as a component of data availability and data quality (18). Completeness, defined as the proportion of data elements that are recorded within a medical record system, regardless of data element values, may influence how data are understood with respect to bias and predictive modeling (19, 20). Datasets with large amounts of missing data may convey a biased result, which would hinder accurate assessment of the data and adversely affect quality improvement initiatives (21). Ehlers et al. previously described the 2020 NEMSIS Public-Release Research Dataset and provided a snapshot of missingness for multiple data fields within this now widely used dataset. For example, documentation of the primary symptom is a required data field that is available in the public use NEMSIS dataset but was found to be missing in 9% of 9-1-1 responses (17). While reporting an improvement in missingness with validity rules initiated in 2017, Ehlers et al. raised concerns that certain data may not be missing at random and described a need to control for this limitation by using covarying elements and sensitivity analyses (17).

Given that children constitute a low proportion of prehospital encounters along with regional data suggesting differences in pediatric assessments being performed compared to adults, it is important to consider the completeness of these assessments and their documentation within the NEMSIS dataset. If vital signs documentation is tied to systemic data management errors within information systems or incomplete *post hoc* documentation, we would expect there to be similar rates of missing values across all age groups. However, if there are different rates of vital sign documentation associated with patient characteristics such as age, this would provide evidence that there are disparities in prehospital patient assessments instead of data being missing at random. Understanding the pattern of missing data could inform clinicians who perform pediatric assessments and contribute these data, and researchers who may use NEMSIS or other large data repositories, on the current state of pediatric prehospital care, which could then be a focus for targeted quality improvement interventions.

In this study, we aimed to assess publicly available data from the NEMSIS dataset to evaluate the documentation of complete sets of vital signs among pediatric versus adult patients. Additionally, we aimed to identify the performance and documentation of key condition-specific assessments for patients with respiratory emergencies, cardiac complaints, and trauma.

Methods

Data Source

We performed a retrospective cross-sectional analysis of EMS encounters from the 2019 NEMSIS dataset, which contains data from 10,062 EMS agencies in 47 states and territories (22). Data were obtained from NEMSIS v.3.4.0, which is managed by the NEMSIS Technical Assistance Center at the University of Utah. Available data were supplemented with additional encounter data by a separate request to the NEMSIS data center. This study was approved by the University of Pittsburgh and Ann and Robert H. Lurie Children's Hospital of Chicago institutional review boards.

Inclusion

We included all encounters seen both by advanced life support (ALS) and basic life support (BLS) clinicians who were transported to the hospital. From these, we excluded encounters with no age listed; cardiac arrests; non-transports or cancelations; scene assists; interfacility transports; and air, water, or specialty transports. Operationalized definitions for each of the exclusion criteria as applied to the NEMSIS dataset are provided in the Supplementary Table. These were excluded considering that patient assessments for these responses may not be representative of the assessment and documentation of a primary transporting EMS unit on a typical 9-1-1 response to a living patient. Cardiac arrest was identified by the presence of any of the following: documentation of a rhythm consistent with cardiac arrest (asystole, ventricular fibrillation, ventricular tachycardia without a pulse, or pulseless electrical activity), primary or secondary impression of cardiac arrest for the encounter, performance of defibrillation, performance of cardiopulmonary resuscitation, a recorded impression that resuscitative efforts were futile, were dead on arrival, or who had a transport destination of a morgue. Scene assists were defined as encounters where a team provided support to a primary EMS unit or if the ambulance was listed as 'standby' or 'public assistance.' Interfacility transports were defined as either scheduled transports, non-emergent transports, transports between hospitals, or transports between a home and a hospital.

Encounter Data

We obtained the following characteristics from included encounters: age, sex, urbanicity, census region, census division, and injury status, which indicates whether the clinician thought the patient suffered a traumatic injury during the encounter. Using previously published age standards, age was grouped into categories of <1 month, 1 month to <1 year, 1 year, 2–5 years, 6–11 years, 12–17 years, and 18 years or older (15). Urbanicity was obtained at the encounter level using a dedicated field within NEMSIS that classified encounters as occurring in urban, suburban, rural, or wilderness settings. EMS agency data included ALS or BLS service level, ambulance service organization type, and nonprofit status. For missing covariables, we classified these into a separate "missing" category.

Outcome Data

We identified the documentation of any systolic blood pressure, heart rate, and respiratory rate, collectively defined as a full set of vital signs. We elected to use this definition based on previous literature reporting on the performance of vital signs for children in the prehospital setting (10, 12, 13, 15), as well as the NASEMSO National Model EMS Clinical Guidelines (9), which identify these as key vital signs for all patients. Temperature was not included as it is not consistently obtained in the prehospital setting. Weight and diastolic blood pressure are currently unavailable in the national NEMSIS dataset. Our primary outcome was the complete documentation of vital signs (all three items documented). Our secondary outcomes were: 1) documentation of pulse oximetry and respiratory rate for those with respiratory complaints, 2) documentation of cardiac monitor use in patients with cardiac complaints evaluated by ALS clinicians, and 3) documentation of pain scores and either Glasgow Coma Scale (GCS) motor score, AVPU, or a complete GCS score for trauma patients. Operationalized definitions for each of these sub-groups as applied to the NEMSIS dataset are provided in the Supplementary Table.

Analysis

We calculated descriptive statistics to summarize the data with counts and corresponding percentages for categorical data. We performed univariable and multivariable logistic regression to evaluate the relationship between the documentation of vital signs (primary outcome) and age, while controlling for multiple potential confounders. Our predictor of interest was age (with age $\geq$18 as the referent). Potential confounders were selected based on the available data in NEMSIS that the investigators considered could be associated with differences in patient assessment and included sex, injury status, transport type, census region, urbanicity, organization nonprofit status, and organization type. Sex, injury status, and transport type have previously been associated with the documentation of vital signs in a regional dataset (15). Geographic and organizational characteristics were newly available in this national dataset compared to prior regional studies and considering at least one prior study in adult patients, the investigators *a priori* considered these factors to potentially be associated with pediatric patient assessments (23). All candidate variables were used in the multivariable model. We reported our results as odds ratios (OR) with 95% confidence intervals (CI). Analysis was preformed using R, version 4.1.1.

Results

Study Inclusion

We identified 34,203,087 EMS activations in the 2019 NEMSIS dataset. Of these, 18,918,914 were included for the present study (Figure 1). Among included encounters, 1,212,843 (6.4%) were pediatric (<18 years) and 47.3% were male. There were similar proportions of ALS versus BLS responses attending to adult (84.2% ALS) and pediatric (83.6% ALS) encounters (Table 1). A large proportion of encounters were from the South (46.5%) and from urban settings (83.1%).

Missingness of Vital Signs

The proportions of individual vital signs documentation increased with age, a finding that was noted for heart rate, respiratory rate, and systolic blood pressure (Figure 2). For example, systolic blood pressure was documented in 32.2% of neonates versus 95.5% of adults (Figure 2). Documentation of complete vital signs was lowest in children <1 month old (30.8%) and increased in older age groups. Among children, adolescents (12–17 years) had a similar rate of complete vital signs documentation compared to adults (89.2% versus 91.8%).

The highest proportion of complete vital signs for each age group was documented among encounters in the South (Table 2). A lower proportion of encounters in each category <12 years old had complete vital signs in the Midwest census region compared to other regions. A higher proportion of children in all age groups had complete vital signs documented by for-profit EMS agencies and by private, non-hospital-based ambulance services. For children less than 12 years old, the lowest proportion of complete vital signs was documented by tribal ambulance services.

In univariable analysis, we identified lower odds of complete vital signs assessment in younger patients. These findings persisted in our multivariable analysis (Table 3). The adjusted odds of complete vital signs in patients <1 month of age was 0.03 (95% CI 0.03–0.03) and increased with age to 0.76 (95% CI 0.75–0.77) in those ages 12–17 years old relative to adults. The odds of having a complete set of vital signs documented were higher for those encountered by ALS clinicians (OR 2.10, 95% CI 2.10–2.11), those encountered in the South region (OR 1.43, 95% CI 1.42–1.43), and non-fire-based ambulances (OR 1.44, 95% CI 1.43–1.45). Lower odds of obtaining complete vital signs were associated with nonprofit ambulance organizations (OR 0.68, 95% CI 0.67–0.68).

Sub-Analysis by Complaint Category

Among encounters with respiratory complaints, there was a slight increase in the reporting of respiratory rates in all age categories as compared to other chief complaints (Table 4). Performance of pulse oximetry readings in the pediatric age groups was lower when compared to adult patients. For example, 74.9% of neonates with a respiratory complaint had pulse oximetry readings obtained, compared to 95.1% of adults. Among encounters with cardiac complaints seen by ALS clinicians, monitor use for all pediatric age groups was low (Table 4). For example, monitor use was infrequently documented in children who were 1 year of age (24.4%) compared to adults (80.9%). Among patients with clinician impressions of trauma, the proportion of encounters with documented GCS motor scores, complete GCS scores, or

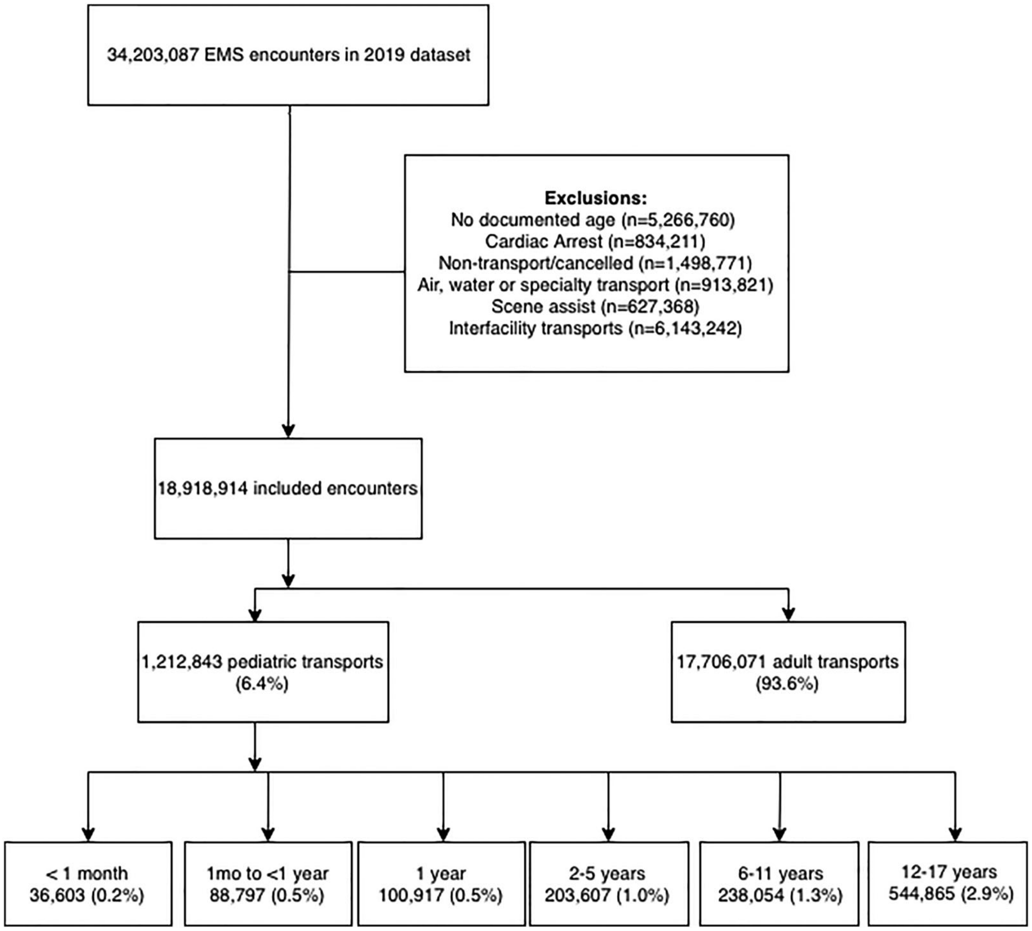

Figure 1. Patient flow diagram.

Table 1. Patient demographics and level of service.

Variables	<1 month n (%)	1 month-<1 year n (%)	1 year n (%)	2–5 years n (%)	6–11 years n (%)	12–17 years n (%)	≥18 year) n (%)	All n (%)
Total	36,603	88,797	100,917	203,607	238,054	544,865	17,706,071	18,918,914
Sex								
Male	18,011 (49.2)	46,775 (52.7)	55,330 (54.8)	115,759 (56.9)	132,477 (55.7)	254,914 (46.8)	8,948,742 (47.3)	8,975,631 (47.3)
Type of service								
BLS	5,807 (15.9)	14,843 (16.7)	15,988 (15.8)	33,079 (16.2)	40,006 (16.8)	89,492 (16.4)	2,803,487 (15.8)	3,002,702 (15.9)
ALS	30,796 (84.1)	73,954 (83.3)	84,929 (84.2)	170,528 (83.8)	198,048 (83.2)	455,373 (83.6)	14,902,584 (84.2)	15,916,212 (84.1)

Sex missing for 102,995 (0.5%) patients in the dataset.

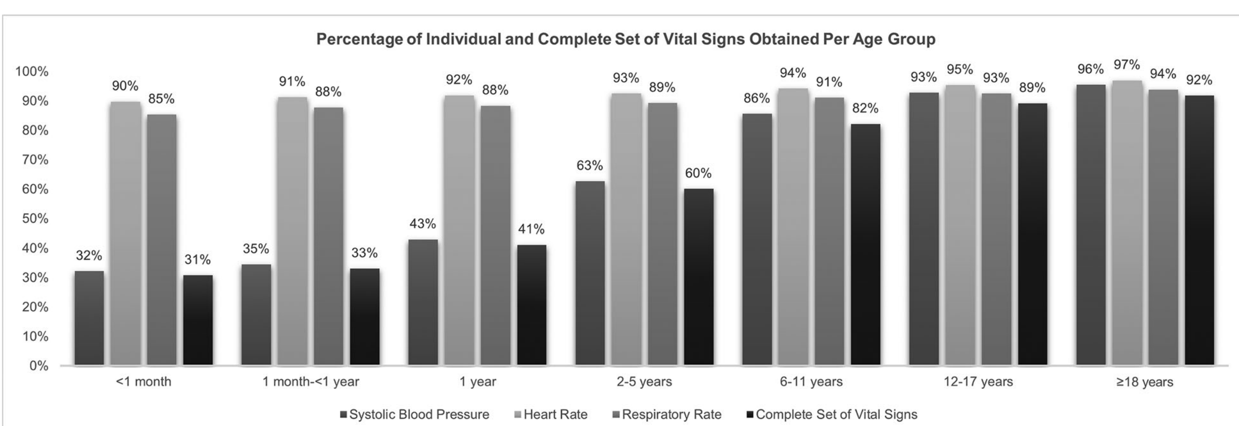

Figure 2. Percentage of patients with individual and complete sets of vital signs obtained by age group.

Table 2. Proportion of complete vital signs by location and agency.

	<1 month n_i/n_f (%)	1 month–<1 year n_i/n_f (%)	1 year n_i/n_f (%)	2–5 years n_i/n_f (%)	6–11 years n_i/n_f (%)	12–17 years n_i/n_f (%)	≥18 years n_i/n_f (%)	All n_i/n_f (%)
Overall Vital Sign	11287/36603 (30.8)	29349/88797 (33.1)	41478/10097 (41.1)	122433/203607 (60.1)	195648/238054 (82.2)	486173/544865 (89.2)	16256051/17706071 (91.8)	17142419/18918914 (90.6)
Census Region								
Midwest	1131/5428 (20.8)	2898/13539 (21.4)	4625/15454 (29.9)	15027/29357 (51.2)	25534/33172 (77.0)	77061/88796 (86.8)	2397411/2663306 (90.0)	2523687/2849052 (88.6)
Northeast	1184/4144 (28.6)	4100/11238 (36.5)	5495/12712 (43.2)	15342/25752 (59.6)	24670/31573 (78.1)	58473/68415 (85.5)	2133382/2387905 (89.3)	2242646/2541739 (88.2)
South	6154/17458 (35.3)	16605/44054 (37.7)	22144/48203 (45.9)	64743/101083 (64.0)	99079/116884 (84.8)	220418/242212 (91.0)	7683724/8220902 (93.5)	8112867/8790796 (92.3)
West	2814/9487 (29.7)	5744/19810 (29.0)	9210/24378 (37.8)	27275/47100 (57.9)	46228/56148 (82.3)	129728/144803 (89.6)	4028516/4417557 (91.2)	4249515/4719283 (90.0)
Missing	4/86 (4.7)	2/156 (1.3)	4/170 (2.4)	46/315 (14.6)	137/277 (49.5)	493/639 (77.2)	13018/16401 (79.4)	13704/18044 (75.9)
Census Division								
East North Central	760/3687 (20.6)	2105/9705 (21.7)	3439/11143 (30.9)	11359/21291 (53.4)	18959/24209 (78.3)	55400/63316 (87.5)	1697776/1881991 (90.2)	1789798/2015342 (88.8)
East South Central	751/1910 (39.3)	1775/4518 (39.3)	2469/5091 (48.5)	6165/10009 (61.6)	9548/11625 (82.1)	24640/27547 (89.4)	916694/986108 (93.0)	962042/1046808 (91.9)
Middle Atlantic	925/3030 (30.5)	3311/8268 (40.0)	4383/9254 (47.4)	11779/18457 (63.8)	17330/21004 (82.5)	38749/43599 (88.9)	1480117/1617588 (91.5)	1556594/1721200 (90.4)
Mountain	1021/3631 (28.1)	2074/7771 (26.7)	3314/8937 (37.1)	10300/17753 (58.0)	18471/22869 (80.8)	54631/61737 (88.5)	1524504/1693567 (90.0)	1614315/1816265 (88.9)
New England	259/1114 (23.2)	789/2970 (26.6)	1112/3458 (32.2)	3563/7295 (48.8)	7340/10569 (69.4)	19724/24816 (79.5)	653265/770317 (84.8)	686052/820539 (83.6)
Pacific	1793/5856 (30.6)	3670/12039 (30.5)	5896/15441 (38.2)	16975/29347 (57.8)	27757/33279 (83.4)	75097/83066 (90.4)	2504012/2723990 (91.9)	2635200/2903018 (90.8)
South Atlantic	3904/11160 (35.0)	9431/27082 (34.8)	12220/28933 (42.2)	39912/63131 (63.2)	64325/74333 (86.5)	135934/146033 (93.1)	4901448/5183344 (94.6)	5167174/5534016 (93.4)
West North Central	371/1741 (21.3)	793/3834 (20.7)	1186/4311 (27.5)	3668/8066 (45.5)	6575/8963 (73.4)	21661/25480 (85.0)	699635/781315 (89.5)	733889/833710 (88.0)
West South Central	1499/4388 (34.2)	5399/12454 (43.4)	7455/14179 (52.6)	18666/27943 (66.8)	25206/30926 (81.5)	59844/68632 (87.2)	1865582/2051450 (90.9)	1983651/2209972 (89.8)
Missing	4/86 (4.7)	2/156 (1.3)	4/170 (2.4)	46/315 (14.6)	137/277 (49.5)	493/639 (77.2)	13018/16401 (79.4)	13704/18044 (75.9)
Urbanicity								
Rural	660/2073 (31.8)	1434/4801 (29.9)	2026/5277 (38.4)	5635/10528 (53.5)	9541/12756 (74.8)	27933/32738 (85.3)	1036671/1155454 (89.7)	1083900/1223627 (88.6)
Suburban	506/1691 (29.9)	1213/4059 (29.9)	1591/4399 (36.2)	5116/9345 (54.7)	8576/11045 (77.6)	23249/26906 (86.4)	897704/988138 (90.8)	937955/1045583 (89.7)
Urban	9638/31116 (31.0)	25433/75773 (33.6)	36256/86666 (41.8)	106704/174470 (61.2)	168519/202671 (83.1)	411219/457326 (89.9)	13545965/14690722 (92.2)	14303734/15718744 (91.0)
Wilderness	135/481 (28.1)	362/1233 (29.4)	447/1317 (33.9)	1330/2675 (49.7)	2387/3209 (74.4)	7396/8805 (84.0)	261262/293658 (89.0)	273319/311378 (87.8)

(*continued*)

Table 2. Continued.

	<1 month n_i/n_f (%)	1 month–<1 year n_i/n_f (%)	1 year n_i/n_f (%)	2–5 years n_i/n_f (%)	6–11 years n_i/n_f (%)	12–17 years n_i/n_f (%)	≥18 years n_i/n_f (%)	All n_i/n_f (%)
Missing	348/1242 (28.0)	907/2931 (30.9)	1158/3258 (35.5)	3648/6589 (55.4)	6625/8373 (79.1)	16376/19090 (85.8)	514449/578099 (89.0)	543511/619582 (87.7)
Organizational Tax Type								
For Profit	2780/8200 (33.9)	6912/17948 (38.5)	10215/20941 (48.8)	28241/41229 (68.5)	42530/48467 (87.8)	111198/119573 (93.0)	3867555/4076413 (94.9)	4069431/4332771 (93.9)
Not For Profit	1946/6510 (29.9)	5480/16125 (34.0)	7470/17935 (41.7)	21292/36366 (58.5)	34367/42596 (80.7)	85614/97355 (87.9)	2880398/3145718 (91.6)	3036567/3362605 (90.3)
Other (e.g., Government	6075/20357 (29.8)	15626/50967 (30.7)	21979/57905 (38.0)	67600/117752 (57.4)	110088/136694 (80.5)	268586/304780 (88.1)	8754156/9669571 (90.5)	9244110/10358026 (89.2)
Missing	486/1536 (31.6)	1331/3757 (35.4)	1814/4136 (43.9)	5300/8260 (64.2)	8663/10297 (84.1)	20775/23157 (89.7)	753942/814369 (92.6)	792311/865512 (91.5)
Organization Type								
Fire Department	5216/17005 (30.7)	12582/40331 (31.2)	17401/46104 (37.7)	52576/92610 (56.8)	86067/108066 (79.6)	212810/243802 (87.3)	6702304/7503856 (89.3)	7088956/8051774 (88.0)
Governmental, Non-Fire	1994/6979 (28.6)	6498/18955 (34.3)	9103/21113 (43.1)	26975/44076 (61.2)	41546/50531 (82.2)	97368/109516 (88.9)	3397317/3667899 (92.6)	3580801/3919069 (91.4)
Hospital	508/2176 (23.3)	1518/5946 (25.5)	2247/6519 (34.5)	7194/12904 (55.8)	12492/15115 (82.6)	30791/33861 (90.9)	1060594/1133584 (93.6)	1115344/1210105 (92.2)
Private, Nonhospital	3062/8821 (34.7)	7383/19477 (37.9)	10859/22724 (47.8)	30175/45142 (66.8)	46251/53192 (87.0)	122581/132471 (92.5)	4308754/4550371 (94.7)	4529065/4832198 (93.7)
Tribal	21/86 (24.4)	37/331 (11.2)	54/321 (16.8)	213/615 (34.6)	629/853 (73.7)	1848/2058 (89.8)	33140/35992 (92.1)	35942/40256 (89.3)
Missing	486/1536 (31.6)	1331/3757 (35.4)	1814/4136 (43.9)	5300/8260 (64.2)	8663/10297 (84.1)	20775/23157 (89.7)	753942/814369 (92.6)	792311/865512 (91.5)

n_I = total number of encounters with a complete set of vital signs documented (heart rate, respiratory rate, systolic blood pressure).
n_f = total number of encounters.

Table 3. Unadjusted and adjusted logistic regressions of complete vital signs assessments.

	Univariable analysis	Multivariable analysis
Variables	OR (95% CI)	Adjusted OR (95% CI)
Age		
Adult (≥18 years)	Ref	Ref
<1 month	0.04 (0.04–0.04)	0.03 (0.03–0.03)
1 month–< 1 year	0.04 (0.04–0.04)	0.04 (0.04–0.04)
1 year	0.06 (0.06–0.60)	0.05 (0.05–0.05)
2–5 years	0.13 (0.13–0.13)	0.12 (0.12–0.12)
6–11 years	0.40 (0.40–0.40)	0.41 (0.40–0.41)
12–17 years	0.74 (0.73–0.74)	0.76 (0.75–0.77)
Sex		
Male	0.88 (0.88–0.89)	0.91 (0.91–0.92)
Possible Injury		
Yes	0.88 (0.88–0.88)	0.87 (0.88–0.89)
Type of Service		
ALS	2.10 (2.10–2.11)	2.11 (2.10–2.11)
Census Region		
Midwest	Ref	Ref
Northeast	0.93 (0.92–0.94)	1.03 (1.02–1.04)
South	1.47 (1.46–1.48)	1.43 (1.42–1.43)
West	1.25 (1.25–1.26)	1.07 (1.07–1.08)
Urbanicity		
Urban	Ref	Ref
Rural	0.77 (0.76–0.77)	0.65 (0.64–0.65)
Suburban	0.84 (0.84–0.85)	0.74 (0.74–0.75)
Wilderness	0.71 (0.70–0.72)	0.65 (0.64–0.66)
Organizational Tax Type		
For profit	Ref	Ref
Nonprofit/Other	0.57 (0.57–0.58)	0.68 (0.68–0.68)
Organizational Type		
Fire	Ref	Ref
Non-Fire	1.62 (1.60–1.62)	1.44 (1.43–1.45)

OR, odds ratio; CI, confidence interval; ALS, advanced life support.

AVPU scales was high for all age groups (Table 4). In contrast, the proportion of patients with traumatic complaints who had documented pain scores was low across all age groups, with the lowest in those <1 month old (34.5%; Table 4). In comparison, 61.7% of adults with traumatic complaints had documented pain scores.

Discussion

We used a nationally representative prehospital dataset to evaluate the completeness of vital signs documentation by EMS clinicians. Documentation of a complete set of vital signs decreased as age decreased and was lowest among neonates. These findings persisted in multivariable logistic regression models which adjusted for patient, agency, and location factors. In children with respiratory, cardiac, or traumatic complaints, we similarly found a lower proportion of cases with documentation of pulse oximetry, cardiac monitoring, and pain score, respectively. These findings have important implications for education of EMS personnel, quality assessment and improvement interventions, performance of retrospective investigations of prehospital databases such as the NEMSIS dataset, and planning for prospective prehospital trials that require the documentation of patient assessments in pediatric prehospital patients.

Our findings expand upon prior regional studies using a much larger nationally representative dataset of prehospital encounters in the United States and adds to an increasing number of investigations occurring from the NEMSIS dataset (10–18, 24). These findings yield valuable information for agency leaders and for future investigators who must plan for differences in patient assessments across age categories and in specific subsets of the prehospital pediatric population. For example, information on the proportion of vital signs assessments across geographic areas and EMS system types has important implications for the planning of EMS research in one or multiple regions. Investigators of multicenter trials or retrospective data evaluations should consider the existing differences in pediatric assessments across regions and EMS system types to best plan education and documentation practices pertinent to investigations and to ensure a population representative of the United States is considered.

Our multivariable analysis demonstrates that differences in pediatric assessments across age categories persisted when controlling for census region and urbanicity, which may not otherwise be considered or assessed when assessing purely regional data (10–16). Our primary findings were also not affected by the level of EMS response, as we demonstrated a similar rate of ALS versus BLS responses for pediatric and adult patients, demonstrating that this issue persists across educational levels of EMS personnel. Still, there may be differential opportunities for education and quality improvement across the United States (12). The association between lower rates of vital signs assessments in younger pediatric patients persisted across urbanicity and various regions within the United States, though a lower proportion of pediatric encounters had vital signs documented in the Midwest census region, suggesting some differential opportunities for improvement.

Our findings with respect to vital signs documentation were noted across a variety of EMS systems. These findings may at least partially be due to the lower frequency of pediatric encounters compared to adults, the frequency and quality of pediatric education for EMS personnel, and general clinician comfort level with pediatric patients (1, 2, 10, 13). Gausche et al. described that paramedics feel increasingly less confident with obtaining vital signs as age decreases (10). Prior work suggests that these findings may be improved upon with targeted educational efforts (12, 25, 26). This pattern is also concerning for lack of properly sized equipment or ability to troubleshoot obtaining accurate vital signs in children. Hewes et al. explained that while most ambulance services have minimum expectations for equipment, it does not always include each size of blood pressure cuff appropriate for various pediatric age groups, which can limit the ability of EMS clinicians to obtain blood pressure measurements (12). When combined with less experience, EMS clinicians may feel hesitant to obtain vital signs that they are uncertain about interpreting, leaving them with limited data to make accurate pediatric assessments. As we improve the pediatric readiness of EMS systems, these data support the core need for a thoughtful approach to providing continuing education on pediatric assessments and suggest a focus on targeted interventions such as obtaining vital signs in this population. It also highlights the importance of EMS personnel having properly sized equipment to facilitate obtaining vital signs.

Table 4. Complaint-specific assessments of those with respiratory complaints, cardiac complaints, or traumatic injuries by age categories.

Variables	<1 month n (%)	1 month–<1 year n (%)	1 year n (%)	2–5 years n (%)	6–11 years n (%)	12–17 years n (%)	≥18 years n (%)	All n (%)
Respiratory patients ***(n = 1,153,410)***								
Total	5,881	13,736	10,242	19,719	17,895	17,486	1,068,451	1,153,410
Pulse oximetry								
Obtained	4,402 (74.9)	11,037 (80.4)	8,742 (85.4)	17,767 (90.1)	16,853 (94.2)	16,422 (93.9)	1,015,708 (95.1)	1,090,931 (94.6)
Not obtained	1,479 (25.1)	2,699 (19.6)	1,500 (14.6)	1,952 (9.9)	1,042 (5.8)	1,064 (6.1)	52,743 (4.9)	62,479 (5.4)
Respiratory rate								
Obtained	5,300 (90.1)	12,698 (92.4)	9,564 (93.4)	18,712 (94.9)	17,280 (96.6)	16,921 (96.8)	1,034,987 (96.9)	1,115,462 (96.7)
Not obtained	581 (9.9)	1,038 (7.6)	678 (6.6)	1,007 (5.1)	615 (3.4)	565 (3.2)	33,464 (3.1)	37,948 (3.3)
Cardiac patients transported by advanced life support ***(n = 824,310)***								
Total	530	874	509	1,201	2,070	5,632	813,494	824,310
Monitor use								
Used	266 (50.2)	292 (33.4)	124 (24.4)	403 (33.6)	1,144 (55.3)	4,033 (71.6)	658,175 (80.9)	664,437 (80.6)
Not used	264 (49.8)	582 (66.6)	385 (75.6)	798 (66.4)	926 (44.7)	1,599 (28.4)	155,319 (19.1)	159,873 (19.4)
Trauma patients ***(n = 3,708,843)***								
Total	**2,747**	**11,679**	**15,964**	**50,617**	**81,031**	**174,707**	**3,372,098**	**3,708,843**
GCS Motor/AVPU								
Obtained	2,440 (88.8)	10,751 (92.1)	14,704 (92.1)	47,033 (92.9)	76,731 (94.7)	166,208 (95.1)	3,225,127 (95.6)	3,542,994 (95.5)
Not Obtained	307 (11.2)	928 (7.9)	1,260 (7.9)	3,584 (7.1)	4,300 (5.3)	8,499 (4.9)	146,971 (4.4)	165,849 (4.5)
Complete GCS								
Obtained	2,258 (82.2)	10,041 (86.0)	13,869 (86.9)	45,159 (89.2)	74,284 (91.7)	161,130 (92.2)	3,127,327 (92.7)	3,434,068 (92.6)
Not obtained	489 (17.8)	1,638 (14.0)	2,095 (13.1)	5,458 (10.8)	6,747 (8.3)	13,577 (7.8)	244,771 (7.3)	274,775 (7.4)
Pain Score								
Obtained	949 (34.5)	3,611 (30.9)	5,344 (33.5)	22,732 (44.9)	48,140 (59.4)	108,794 (62.3)	2,080,728 (61.7)	2,270,298 (61.2)
Not obtained	1,798 (65.5)	8,068 (69.1)	10,620 (66.5)	27,885 (55.1)	32,891 (40.6)	65,913 (37.7)	1,291,370 (38.3)	1,438,545 (38.8)

AVPU = alert, verbal, pain, unresponsive; GCS = Glasgow Coma Scale.

When evaluating vital signs documentation for specific complaints, we found that children with respiratory complaints have a lower proportion of documented pulse oximetry readings relative to adults. We also found that children with cardiac complaints have a lower proportion of documented monitor use when compared to adults. Additionally, we note that blood pressure was the least often documented vital sign in children. This further highlights targets for improved education, as recognition of cardiovascular issues, shock, and respiratory distress may not be optimal in pediatric patients. These components of patient assessment coincide with the Pediatric Readiness in Emergency Medical Services policy statement as areas of need for targeted quality improvement initiatives (7). We also found that pediatric patients with traumatic complaints have lower proportions of having pain scores obtained relative to adults. Clinicians may not have education or exposure to pediatric pain scales, making it particularly challenging to assess and treat pain for younger patients who cannot respond with a numeric rating. This is especially true for children who cannot describe their pain in other ways and require objective assessment scales such as the Wong-Baker FACES or the Faces, Legs, Activity, Cry, Consolability scale (27). Notably, the proportion of pain scores was also low for adults, suggesting that quantifying and documenting pain across the age spectrum presents a challenge. Fortunately, each age group had a high proportion of documentation of GSC motor or total scores, and the AVPU scale for alertness, which are known predictors of outcomes for trauma patients (28). Because children often need modified GCS scores due to their age, we believe that allowance of these modifications in our data set resulted in its high rate of documentation.

Out study highlights additional opportunities to improve pediatric education, readiness, and documentation within the NEMSIS dataset relative to pediatric patient care. Potentially, vital signs acquisition may be improved through pediatric emergency care coordinators, though this could not be investigated in the present study. These coordinators may serve as key educators to ensure EMS agencies have appropriate pediatric equipment and provide tailored education to enhance the assessment of pediatric patients. An important limitation of the NEMSIS dataset that could influence future pediatric quality improvement and pediatric readiness initiatives is that APGAR scores are not contained in this national dataset (7). Similarly, pediatric weights and Broselow tape colors are not collected in this dataset, which affects the potential to perform research focusing on weight-based dosing of pediatric medications and prevention of dosing errors (7). As efforts continue to increase clinician education on pediatric assessments and proper equipment sizing, incorporation of these additional key elements of pediatric assessment in the national public dataset could help to evaluate the implementation and effectiveness of pediatric readiness initiatives.

Limitations

Out study had several limitations. The NEMSIS dataset does not contain data on all EMS encounters in the United States. However, because it reports on >1 million pediatric encounters annually from over 10,000 EMS agencies in 47 states and territories, we believe that this provides generalizable evidence of the state of pediatric assessments in the United States. Some of the variables that we used for adjustment in our multivariable models were themselves subject to higher rates of missingness. We attempted to address this by including missing data fields as a separate value in our multivariable analysis; however, these speak to challenges with

EMS documentation beyond vital signs alone. The narrative portion of EMS documentation was not searched, and it is possible that some data elements were included in these sections but not documented in the locations from which NEMSIS obtains its patient assessment data. Additionally, it is possible that vital signs were assessed, but not documented in the patient care record. While documentation of vital signs could represent a lack of assessment or lack of documentation following a completed assessment, it would not be expected that a sole lack of documentation would vary substantially by age categories and instead suggests differences in patient assessments across these age groups. Regardless of the reason, these differences in documented vital signs across age groups have important implications for education of EMS personnel and future research using similar datasets.

Conclusions

Documentation of a complete set of vital signs occurs less frequently in pediatric patients than adult patients in the prehospital setting. This pattern persists across urbanicity, various regions within the United States, and level of response. Documentation of condition-specific assessments of those with cardiac, respiratory, and traumatic complaints also occurs less frequently in pediatric patients. These findings shed light on current pediatric prehospital clinical care and documentation and can be used for more targeted approaches to pediatric education in various EMS systems. Our data provide a benchmark report that establishes a national baseline for obtaining pediatric vital signs in various age groups and can inform future research efforts using this national dataset or aiming to prospectively collect data that includes these assessments.

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