



## Outcomes of patients discharged from the pediatric emergency department with abnormal vital signs

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### ABSTRACT

**Background:** Vital signs (VS) are used to triage and identify children at risk for severe illness. Few studies have examined the association of pediatric VS at emergency department (ED) discharge with patient outcomes.

**Objective:** To determine if children discharged from the ED with abnormal VS have high rates of return visits, admission or adverse outcomes.

**Methods:** We conducted a retrospective cohort study of children discharged from 2 pediatric EDs with abnormal VS between July 2018–June 2019. We queried electronic health records (EHR) for children ages 0–18 years discharged from the ED with abnormal last recorded VS. VS were considered erroneously entered and thus excluded from analysis if heart rate was <30 or ≥ 300, respiratory rate was 0 or ≥ 100 or oxygen saturation was <50. Patients who were declared deceased at index visit were excluded. Demographic, clinical, and outcome data including return visits within 48 h and adverse outcomes after the initial ED discharge were obtained.

**Results:** Of the 97,824 children evaluated in the EDs during the study period, 17,661 (18.1%) were discharged with abnormal VS. 404 (2.28%) returned to the ED, of which 95 (23.5%) were admitted for the same chief complaint within 48 h. In comparison, the 48-h return rate for children discharged with normal VS was 2.45% ( $p = 0.219$ ). Children discharged with abnormal VS were more likely to return if they had 2 or more abnormal VS (OR 1.6; 95% CI 1.23–2.07), were less than 3 years old (OR 1.69, 95% CI 1.39–2.06) or their initial acuity level was high (OR 1.34; 95% CI 1.1–1.63). Higher initial acuity level and age less than 3 years were also associated with admission at revisit (OR 2.58; 95% CI 1.59–4.2; OR 2.20, 95% CI 1.36–3.55). Four of the children who returned required PICU admission, but none died, required CPR or endotracheal intubation.

**Conclusion:** Although many children were discharged from the ED with abnormal VS, few returned and required admission. Having 2 or more abnormal VS, age less than 3 years and higher acuity increased odds of revisit. Few children suffered serious adverse outcomes.

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### 1. Introduction

Vital signs (VS) are used to triage and identify children at risk of severe illness [1–9]. However, it is not uncommon for children to be discharged home from the emergency department (ED) with abnormal VS if they are determined to be clinically well and safe for discharge.

In adult populations, abnormal VS at ED discharge have been shown to correlate with adverse outcomes including revisits to the ED, hospital admissions and death [10–12]. Similarly, elevated heart rate or low

systolic blood pressure at discharge from urgent care centers predicted probability of ED revisit and hospitalization [13]. Patients with two or more abnormal VS at ED discharge had the highest odds of admission within 7 days and a positive predictive value of 22% for a 30-day readmission or death [14,15].

Children often have abnormal VS in the ED but there is a paucity of literature examining the outcomes of children discharged home with abnormal VS. Most pediatric patients who meet criteria for systemic inflammatory response syndrome by VS during their ED visits are ultimately discharged home without the need for admission or representation to the ED [2,16]. Winter et al. reported that the prevalence of pediatric patients with at least one abnormal VS at the time of ED discharge was high (17%) but severe adverse events were rare (0.43%) [17]. Other similar pediatric studies have focused on individual abnormal VS, namely tachycardia [18,19]. Tachycardia at ED discharge has been associated with an increased risk of revisit but not future receipt of clinically important interventions or admission at revisit [18].

**Abbreviations:** VS, Vital signs; ED, emergency department; EHR, electronic health record; CPR, cardiopulmonary resuscitation; PICU, pediatric intensive care unit; CI, confidence interval; OR, odds ratio.

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The objective of this study was to determine if having abnormal VS at the time of ED discharge was associated with an increased rate of return visits, admission to the hospital and adverse events within 48 h of ED discharge. Secondly, we sought to determine if the number of abnormal VS or specific VS were associated with increased odds of revisit or admission to the hospital within 48 h.

## 2. Methods

This was a retrospective cohort study of all children discharged from two pediatric tertiary level, academic EDs with abnormal VS between June 2018 and July 2019. The study setting included Nemours Children's Hospital, Delaware in Wilmington, Delaware with an ED census of 59,139 and Nemours Children's Hospital, Florida in Orlando, Florida with an ED census of 38,685 during the study period.

The electronic health record (EHR) (EPIC) was queried for children ages 0–18 years discharged from the ED during the study period with abnormal VS. The study period was chosen to include an entire calendar year and to capture seasonal variation in presenting complaints.

Vital signs were defined as abnormal if flagged in the EHR indicating a heart rate, respiratory rate or blood pressure outside of 5th and 95th percentiles for age, an oxygen saturation < 95% and temperature < 97 F or > 100.4 F. Heart rate, respiratory rate and blood pressure limits in the EHR were established by an enterprise-wide interdisciplinary

group of providers and nurses based on existing literature and implemented on June 25, 2018, prior to onset of data collection (Table 1) [20,21]. The last recorded set of VS were defined as the discharge VS. Vital signs were considered erroneously documented and thus excluded from the analysis if heart rate was <30 or ≥ 300, respiratory rate was 0 or ≥ 100 or oxygen saturation was <50. Demographic, clinical and outcome data including gender, ethnicity/race, age, acuity level, ICD-10 diagnoses, return visits and admissions for related conditions in 48 h after initial ED discharge were obtained. Acuity level was defined as high if the Emergency Severity Index (ESI) at the initial visit was 1, 2 or 3. An ESI triage level of 4 or 5 represented low acuity [8]. Annual departmental statistics for both EDs including number of ED visits, number of ED discharges, number of return visits in 48 h and admission rates were collected. The EHR charts of patients with admission at revisit were manually reviewed by the principal investigator. Data on admission location, primary ICD-10 diagnosis and interventions were extracted.

The primary outcomes were revisit to the ED within 48 h and disposition at return visit. The secondary outcomes were admission location (inpatient, operating room, PICU) and adverse outcomes during admission. Adverse outcomes were defined as those requiring cardiopulmonary resuscitation (CPR), endotracheal intubation, surgical intervention, admission to the pediatric critical care unit (PICU) or death at revisit.

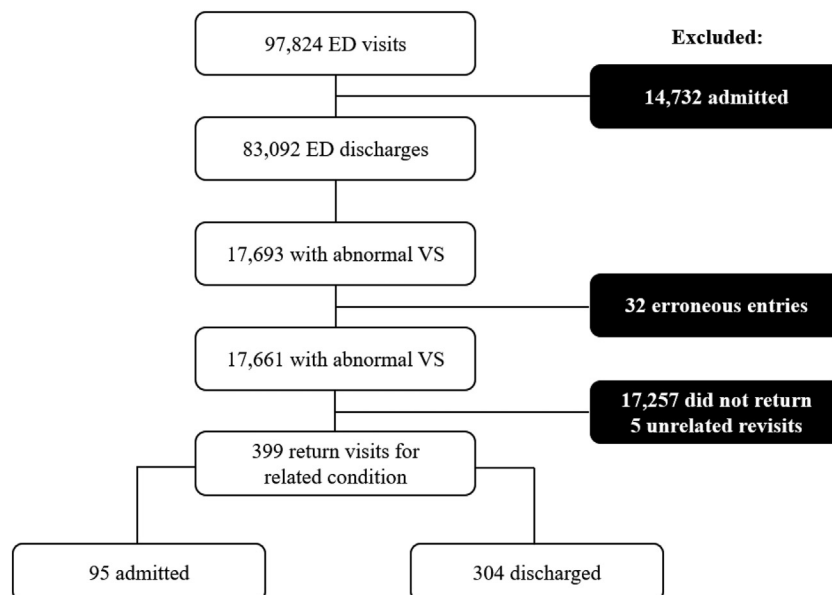
Statistical analysis was performed using SPSS software (Version 25). Descriptive statistics, t-tests and Pearson chi-square coefficients were calculated. Univariate and multivariate logistic regression analysis were performed to analyze individual VS and their association with revisit and admission at revisit. The study was approved by the Nemours institutional review board.

**Table 1**  
Normal vital sign parameters by age

Age	Heart rate	Respiratory rate	Systolic blood pressure
0–12 weeks	113–171	27–62	>60
3–5 months	108–167	25–58	>70
6–8 months	104–163	23–54	>70
9–11 months	101–160	22–51	>70
12–17 months	97–157	21–51	>70
18–23 months	92–154	20–45	>72
2 years	87–150	18–42	>74
3 years	82–146	18–40	>76
4–5 years	77–142	17–37	>78
6–7 years	71–137	16–35	>82
8–11 years	66–129	15–31	>90
12–14 years	61–121	13–28	>90
15–19 years	57–115	13–26	>90

## 3. Results

There were a total of 97,824 children evaluated in the EDs during the study period of which 83,092 were discharged home. We identified 17,661 (21.3%) children discharged with abnormal VS. Of these, 399 (2.26%) children returned to the ED within 48 h for a related condition and 95 (23.8%) of these children were admitted to the hospital at revisit (Fig. 1). Return rates did not significantly differ compared to children discharged with normal VS (2.45% compared to 2.26%;  $p = 0.219$ ).



**Fig. 1.** Summary of included and excluded data.

**Table 2**  
ED return visits and admissions by number of abnormal vital signs

	No revisit (n = 17,257)	Revisit (n = 399)	p-value	Odds Ratio (95% C-I)
Abnormal vital signs				
1	15,226 (88.2%)	328 (82.2%)	< 0.001	1.62 (1.25–2.11)
≥ 2	2031 (11.8%)	71 (17.8%)		
	Discharged at revisit (n = 304)	Admitted at revisit (n = 95)		
Abnormal vital signs				
1	256 (84.2%)	72 (75.8%)	0.061	1.70 (0.97–2.99)
≥ 2	48 (15.8%)	23 (24.2%)		

Of those children discharged from the ED with abnormal VS, there were no significant differences in ED revisit within 48 h or admission at revisit by gender, ethnicity or race. Children discharged from the ED with abnormal VS were more likely to revisit the ED within 48 h if they were younger than 3 years old (OR 1.69, 95% CI 1.39–2.06) or their initial acuity level was higher (ESI triage level 1,2 or 3) (OR 1.36, 95% CI 1.12–1.66). Children discharged from the ED with abnormal VS were also more likely to require admission at revisit if they were younger than 3 years old (OR 2.20, 95% CI 1.36–3.55) or their initial acuity level was high (OR 2.54, 95% CI 1.56–4.1) (Table 3, Table 4).

Children discharged from the ED with abnormal VS were more likely to return to the ED within 48 h if they had 2 or more abnormal VS (OR 1.62, 95% CI 1.25–2.11) compared to 1 abnormal VS, but they were not significantly more likely to require admission at revisit (OR 1.70, 95% CI 0.972–2.987, p = 0.061) compared to children discharged with 1 abnormal VS (Table 2).

Univariate and multivariate logistic regression analysis were performed to analyze individual VS and their association with revisit and admission at revisit. Using univariate regression analysis, among children discharged with abnormal VS, abnormal temperature at ED discharge was a significant predictor of ED revisit within 48 h (OR 1.88, 95% CI 1.50–2.36) and this remained true after adjusting for the effect of other vital signs in multivariate analysis (OR 1.92, 95% CI 1.25–2.95). Heart rate, blood pressure, respiratory rate and oxygen saturation did not individually have a significant association with revisit (Table 5). Among children discharged with abnormal VS, abnormal oxygen saturation at ED discharge while not a predictor for ED revisit was a significant predictor of admission in those patients that returned within 48 h (OR 4.24, 95% CI 3.39–5.30). Of those that returned to the

**Table 3**  
Return visits within 48 h

	No revisit (n = 17,257)	Revisit (n = 399)	p-value	Odds Ratio (95% C-I)
<b>Gender</b>				
Male	9436 (54.7%)	210 (52.6%)	0.417	0.921(0.75–1.12)
Female	7821 (45.3%)	189 (47.4%)		
<b>Age (years)</b>				
< 3 years	5,93	4.68	< 0.001	
≥ 3 years	6516 (37.7%)	202 (50.6%)	< 0.001	1.69 (1.39–2.06)
<b>Ethnicity</b>				
Non-Hispanic/Latino	11,996 (69.5%)	265 (66.4%)	0.296	
Hispanic or Latino	5177 (30%)	133 (33.3%)		
Unknown	84 (0.5%)	1 (0.3%)		
<b>Race</b>				
White	8322 (48.2%)	195 (48.9%)	0.982	
Black/African American	4611 (26.7%)	103 (25.8%)		
Asian	295 (1.7%)	8 (2.0%)		
Other	3927 (22.8%)	91 (22.8%)		
Unknown	102 (0.6%)	2 (0.5%)		
<b>ESI triage level</b>				
High (1,2,3)	7540 (43.7%)	205 (51.4%)	0.002	1.36 (1.12–1.66)
Low (4,5)	9701 (56.2%)	194 (48.6%)		

ED, all children with abnormal oxygen saturation at the time of discharge on the index visit were admitted and thus, oxygen saturation was excluded from multivariate analysis. None of the remaining VS showed a significant association with admission at 48 h (Table 6).

Of those children with abnormal VS who were admitted within 48 h of ED discharge, the majority were admitted to the general pediatric ward (92.6%). Three children required surgical intervention; two had acute appendicitis and one required incision and drainage of an abscess. Four children required admission to the PICU. All four patients were admitted for progression of respiratory illness (three with viral respiratory illnesses and one with pneumonia) and required oxygen therapy during admission. No children required cardiopulmonary resuscitation or endotracheal intubation on revisit and there were no deaths in the studied cohort.

**4. Discussion**

To our knowledge, this is the largest and only multi-center study examining the presence of adverse outcomes in pediatric patients discharged from the ED with abnormal VS. Many children are discharged from the ED with abnormal VS. Few returned to the ED and required admission within 48 h for a related condition. In our study, 21.3% of children were discharged from the ED with at least one abnormal VS and few experienced serious adverse outcomes. Similarly, Winter et al., found the prevalence of pediatric patients discharged from the ED with at least one abnormal VS was 17% but severe adverse events were rare (0.43%) [17].

In our study, children with two or more abnormal VS at ED discharge had increased odds of ED revisit at 48 h compared to children with one abnormal VS. However, the presence of >1 abnormal VS did not increase likelihood of admission at revisit. In adults, having 2 or more

**Table 4**  
Disposition at return visit within 48 h

	Discharged (n = 304)	Admitted (n = 95)	p-value	Odds ratio (95% C-I)
<b>Gender</b>				
Male	158 (52%)	52 (54.7%)	0.638	1.12 (0.70–1.77)
Female	146 (48%)	43 (45.3%)		
<b>Age (years)</b>				
< 3 years	5.13, SD 4.63	3.27, SD 4.01	< 0.001	
≥ 3 years	140 (46%)	62 (65.3%)	0.001	2.20 (1.36–3.55)
<b>Ethnicity</b>				
Non-Hispanic or Latino	195 (64.2%)	70 (73.7%)	0.207	
Hispanic or Latino	108 (35.5%)	25 (26.3%)		
Unknown	1 (0.3%)	0		
<b>Race</b>				
White/Caucasian	143 (47.1%)	52 (54.7%)	0.593	
Black/African American	81 (26.6%)	22 (23.2%)		
Asian	6 (2%)	2 (2.1%)		
Other	73 (24%)	18 (18.9%)		
Unknown	1 (0.3%)	1 (1.1%)		
<b>ESI triage level</b>				
High (1,2,3)	140(46%)	65 (68.4%)	<0.001	2.54 (1.56–4.1)
Low (4,5)	164 (54%)	30 (31.6%)		

**Table 5**  
Logistic regression analysis by vital signs for revisits within 48 h

Vital Signs	Univariate analysis		Multivariate analysis	
	p value	OR (95% CI)	p value	OR (95% CI)
Heart rate	0.0948	1.22 (0.97–1.53)	0.5449	1.15 (0.73–1.79)
Blood pressure	0.5122	0.90 (0.67–1.22)	0.7745	1.07 (0.66–1.74)
Temperature	<0.001	1.88 (1.5–2.36)	0.0029	1.92 (1.25–2.95)
Respiratory rate	0.8325	0.93 (0.49–1.76)	0.9774	1.02 (0.36–2.84)
Oxygen saturation	0.2781	1.75 (0.64–4.80)	0.7791	0.75 (0.10–5.50)

**Table 6**  
Logistic regression analysis by vital signs for admission at revisit

Vital Signs	Univariate analysis		Multivariate analysis	
	p value	OR (95% CI)	p value	OR (95% CI)
Heart rate	0.8160	1.06 (0.63–1.80)	0.2647	1.50 (0.73–3.08)
Blood pressure	0.5843	0.83 (0.43–1.61)	0.3814	1.49 (0.61–3.63)
Temperature	0.7628	0.92 (0.54–1.56)	0.3193	1.52 (0.67–3.48)
Respiratory rate	0.0704	3.21 (0.91–11.35)	0.0555	6.44 (0.96–43.35)
Oxygen saturation	0.000	4.24 (3.39–5.30)	**	**

\*\* not calculated.

abnormal VS increased odds of admission to the hospital within 7 days of ED discharge [14] with the presence of three or more VS abnormalities at ED discharge increasing risk of death fourfold [15]. Although our study did not demonstrate a significant number of adverse outcomes even among those children with 2 or more abnormal VS, one can postulate that children with multiple VS abnormalities may represent a cohort of patients that still necessitate close re-evaluation prior to ED discharge.

Prior pediatric studies have reported younger age [18,22,23] and higher triage acuity levels to be associated with 72-h revisit and admission to the hospital [1,8,24]. Similarly, our results also show that age < 3 years and higher acuity level at the index ED visit increased odds of ED revisit within 48 h and admission at revisit in children discharged from the ED with abnormal VS. This suggests that in addition to those children with multiple abnormal VS, children <3 years of age and those with higher acuity levels may require close re-evaluation prior to ED discharge if they have abnormal VS.

There is a paucity of literature evaluating specific VS abnormalities in pediatric patients at ED discharge as predictors of outcomes following ED discharge. Previous work by Wilson et al. did report tachycardia at discharge to be an independent predictor of revisit although it was not associated with the need for hospitalization [18]. In contrast, in our study, abnormal temperature was the only VS that increased both odds of revisit to the ED and subsequent admission to the hospital at ED revisit. While not associated with higher odds of revisit, all patients who did return with initial abnormal oxygen saturations were also admitted. Future research would benefit from larger scale studies aimed at deriving prediction tools based on VS abnormalities.

Very few children in our study required critical care at revisit and most were admitted for conditions related to progression of their illness. This supports previous literature showing that most children admitted to the PICU within 72-h from the index ED visit returned for disease-related progression [25]. Similarly, previous literature has shown that admissions at ED revisit were not necessarily reflective of illness severity or inappropriate ED care at index visit [26,27] but rather related to progression of illness, as in our study.

Although this study showed that children with multiple abnormal VS at ED discharge had higher odds of ED return visits, adopting the practice of normalizing VS prior to discharge is not necessarily supported. In adults, efforts to reduce the number of patients discharged from the ED with abnormal VS reduced return visits in 72 h without significantly changing ED treatment plans or admission rates [28].

Interestingly, although the resolution of tachycardia in pediatric patients during ED visits was more likely to result in ED discharge, this was associated with an increased risk of revisit within 72 h but not admission at revisit [19]. These inconsistent findings coupled with the suggestion that individual VS inconsistently predict return visits, admissions and adverse outcomes puts the practices of normalizing VS prior to discharge into question and suggests more research is needed in this field.

#### 4.1. Limitations

This was a retrospective study that relied on VS documentation in the EHR chart. The last set of recorded VS may not reflect discharge VS in every patient resulting in failure to capture all patients discharged with abnormal VS or the inappropriate inclusion of children whose initial triage VS were abnormal and not repeated prior to discharge. Additionally, our analysis did not compensate for potential confounders such as medications or medical conditions that cause VS abnormalities but are not reflective of severity of illness. However, the goal of this study was not to identify specific VS thresholds predictive of illness but rather to determine if the presence of abnormal VS increased the risk of return visits and adverse effects. Given the large sample size studied, it is unlikely that either of these limitations significantly impacted the outcomes.

This study relied on 48-h returns as a surrogate marker for adverse ED outcomes despite previous data suggesting that return visits are not the best measure of quality of care [29], resource utilization, or severity of illness [30]. Until a validated marker for adverse outcomes is available, it would be impractical to manually review charts of every ED patient and thus, it was assumed that any patient with clinically significant adverse outcomes would likely return to the hospital within that time frame and be captured in our study.

Furthermore, all possible return visits may not have been captured if patients sought care at a different medical facility other than the one they initially visited. This may have underestimated the true number of adverse events and future research would benefit from regional studies to capture all events.

#### 5. Conclusions

Although many children are discharged from the ED with abnormal VS, revisit within 48 h and need for admission at revisit are rare.

Younger age, more than one abnormal VS and higher acuity levels at the index ED visit were associated with revisit, perhaps suggesting the combination of these, rather than individual VS may be more important for clinicians when making disposition decisions.

Future directions should include additional research into age-specific VS thresholds and their predictive value for identifying children at risk of severe illness. Until then, it is important that providers continue to take into consideration the overall clinical picture and appearance of the patient without relying solely on VS prior to making disposition decisions.

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### CRediT authorship contribution statement

**Magdalena Kazmierczak:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Amy Thompson:** Writing – review & editing, Supervision, Project administration, Methodology, Formal analysis, Conceptualization. **Andrew DePiero:** Writing – review & editing, Supervision, Project administration, Methodology, Formal analysis, Conceptualization. **Steven M. Selbst:** Writing – review & editing, Supervision, Project administration, Conceptualization.

### Declaration of Competing Interest

The authors have no disclosures or conflicts of interest.

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