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# Selected Topics: Prehospital Care

# Accuracy of Prehospital Services' Estimated Time to Arrival for Ground Transport to the Emergency Department

Jessica Fozard, DO, Brent Becker, MD, Tucker Lurie, MD, and Aizad Dasti, MD

Department of Emergency Medicine, WellSpan York Hospital, York, Pennsylvania

*Reprint Address:* Brent A. Becker, MD, Department of Emergency Medicine, WellSpan York Hospital, 1001 S George Street, York, PA 17403

**☐ Abstract—Background: Emergency medical services (EMS) transporting patients to the emergency department (ED) typically call ahead to provide an estimated time to arrival (ETA). Accurate ETA facilitates ED preparation and resource allotment in anticipation of patient arrival. Objective: The study purposed to determine the accuracy of ETA provided by EMS ground units. Methods: We performed a single-center, prospective, observational study of ED patients arriving via EMS ground transport. The primary outcome was the time difference between EMS-reported ETA and actual time of arrival (ATA). The difference between ATA and ETA was compared using the two-sided Wilcoxon Signed-Rank Test. Subgroup analysis was performed to evaluate ETA accuracy for specific types of transports and assess variability by month and time of day. Results: We included 1176 patient transports in the final analysis. The overall median difference ATA-ETA was 3 min (interquartile range 1–5 min) with a range of −26–48 minutes ($Z = -25.139$, $p < 0.001$). EMS underestimated ETA in 961 cases (81.7%), and 94 ETAs (8.0%) were accurate to within 1 min. The largest difference between ATA and ETA occurred between 07:00–07:59 and 16:00–16:59 (5 min, interquartile range 2–7). Conclusion: Our data demonstrate that prehospital providers underestimate time to ED arrival in most ground transports; however, the median difference between estimated and actual time to arrival is small.** 

**☐ Keywords—emergency medical services; transportation of patients; estimated time to arrival**

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## Introduction

### *Background*

Emergency department (ED) efficiency depends on a multitude of factors, including anticipation of patient inflow and proper allocation of resources. Real-time ED operations rely heavily on the estimated time to arrival (ETA) provided by emergency medical services (EMS). Incorporation of prehospital arrival notification data from EMS has been shown to improve the performance of ED forecasting models and the accuracy of EMS-provided ETA impacts ED readiness and ability of personnel to effectively care for both current and anticipated patients (1,2). However, inaccurate ETA can negatively impact patient care. An overestimated ETA potentially renders ED staff unprepared to deliver critical actions when the patient arrives unexpectedly. Conversely, an underestimated ETA may delay other important, time-sensitive clinical duties as ED staff prepare prematurely and spend unproductive minutes awaiting the patient's arrival. Such departures from standard ED flow also delay the initial physician evaluation of other patients, as observed with

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trauma activations (3). A single inaccurate ETA can negatively affect the care of multiple patients in the ED and systemic ETA overestimation could potentially impact services within an entire hospital.

Research from the early 1990s suggested that EMS providers consistently underestimate ETA in a large majority of cases, but only by a few minutes (min) on average (4). More recently published data on trauma patients demonstrated a larger ETA underestimation with a median difference closer to 10 min. However, assessment of EMS ETA accuracy for the undifferentiated population of all patients undergoing transport to the ED is missing from the current literature (5). Given the impact of ambulance arrivals on ED operations, it is important to identify any systemic inaccuracies in EMS-provided ETA. Such discrepancies could signal otherwise unrecognized inefficiencies in prehospital care and opportunities to improve treatment of ED patients.

### *Goals of this Investigation*

The objective of the study was to determine the current accuracy of prearrival ETA provided by EMS ground units transporting patients to the ED.

## Methods

### *Study Design and Setting*

We performed a single-center, prospective, observational study examining the accuracy of prearrival ETA provided by EMS ground units transporting patients to the ED. The study was conducted at a 596-bed, Level I trauma center in South Central Pennsylvania functioning as the regional chest pain and certified stroke center. The ED treats approximately 85,000 patients annually with over 20,000 arriving via EMS. The hospital receives transports from approximately 35 different EMS agencies covering the surrounding 911 square miles (2360 $km^2$) and serving a population of over 520,000. The hospital catchment area encompasses a broad mix of urban, suburban, and rural locations with transport times ranging from < 5 min to > 45 min. All EMS transports in Pennsylvania are required to contact the receiving facility and provide a prearrival alert, typically relaying patient demographics, chief complaint, and ETA. Per Pennsylvania state protocol, EMS responses are tiered based on the severity of the call. Lights and sirens are restricted to use for patients necessitating immediate medical intervention beyond the capabilities of the ambulance crew, or other extenuating circumstances (6). The study was approved by the institutional review board with waiver of informed consent.

### *Selection of Participants*

All EMS reports were received via the medical command radios positioned at the receiving location of the ED and monitored by the flow nurse and ED clerks. All prearrival calls from EMS units en route to the ED were eligible for inclusion. Air medical transports and alerts with missing data were subsequently excluded from analysis. Initial pilot data were collected from consecutive prearrival calls in late August 2018, followed by main data collection from consecutive prearrival calls between December 2018 and February 2019. Data collection was terminated in February after reaching goal enrollment. EMS providers were not aware that the study was being performed.

### *Data Collection and Measurements*

Data were recorded contemporaneously during prearrival calls using a standardized data collection form completed by the flow nurse or ED clerk. We collected the following information during each prearrival call: EMS unit, date/time of call, age/gender of patient, chief complaint, type of call (medical, trauma or medical command), and ETA. The actual time of arrival (ATA) was defined by the time-stamp generated immediately upon initiation of the patient registration process. Transport patients were taken directly from the ambulance bay to the flow desk for registration, representing a distance of approximately 100 feet. Patients were registered by ED clerks whose primary function was registration of EMS patients. The difference between EMS ETA and ATA was calculated for each patient transport included in the study.

### *Outcomes*

The primary outcome was the median difference between the ETA and ATA. Secondary outcomes were the differences between ETA and ATA for specific subgroups, including medical patients, trauma patients, medical command calls, trauma bay activations, potential acute coronary syndrome (ACS), suspected strokes, and cardiac arrests. Potential ACS was defined as patients presenting with chest pain, dyspnea, or other symptoms specifically concerning for ACS. Suspected strokes were defined as patients presenting with focal neurologic deficits concerning for stroke or transient ischemic attack.

### *Data Analysis and Sample Size*

Descriptive statistics of continuous and categorical variables were reported as medians with interquartile ranges (IQR) and percentages, respectively. Normality of data was assessed using the Shapiro-Wilk test. ETA and

ATA were compared using two-sided Wilcoxon signed-rank test for the overall cohort and for each of the six subgroups. Any ETA provided as a range (e.g., 5–10 min) was converted to the midpoint value (e.g., 7.5 min) for analysis, similar to precedent published literature (4,5). Potential differences in ETA accuracy by month and time of day were assessed via the Kruskal-Wallis test by ranks. All tests were two-tailed, and $p$-values $< 0.05$ were considered statistically significant with Bonferroni correction applied for subgroup analysis ($p < 0.008 = 0.05/6$ comparisons). Data were compiled using Microsoft Excel 2010 (Microsoft, Redmond, WA) and analysis was performed with IBM SPSS Statistics for Windows version 24.0 (IBM Corp, Armonk, NY).

Pilot data at our institution reported an average difference between ETA and ATA of 4.02 min (SD 5.61). Assuming $\alpha$ (two-tailed) $= 0.05$ and power 90% ($\beta = 0.1$) yielded a required sample size of 24 patients. We planned to include 1500 patient encounters to facilitate subgroup analysis of less frequent types of prearrival calls and allow for missing data in up to 25% of patients.

## Results

### *Characteristics of Study Subjects*

We collected data for a total of 1550 EMS transports. After excluding 374 (24.1%) patient encounters for missing data, we included 1176 (75.9%) transports in the analysis. Of these, 192 (16.3%) were collected in August 2018 during the initial pilot, and the additional 984 (84.7%) were collected from December 2018 to February 2019. Median patient age was 64 years (IQR 42–79.5) and 54.3% were female. Medical and trauma transports comprised 1011 (86.0%) and 165 (14.0%) prearrival calls, respectively. Physician medical command was requested for 74 (6.3%) patients. Subgroups consisted of 20 (1.7%) trauma activations, 110 (9.4%) ACS, 28 (2.4%) stroke, and 7 (0.6%) cardiac arrest (Figure 1). Prearrival calls were provided by 257 different units, with each unit transporting between 1 and 44 patients over the study period.

### *Main Results*

The overall median ETA was 5 min (IQR 5–10 min) with a range of 0–60 min and median ATA was 10 min (IQR 7–12 min) with a range of 0–83 min. The overall median difference ATA-ETA was 3 min (IQR 1–5 min) with a range of −26–48 min ($Z = -25.139$, $p < 0.001$), as seen in Table 1. ATA, ETA, and ATA-ETA each failed the Shapiro-Wilks test of normality (0.733–0.825, $p < 0.001$). Overall, EMS underestimated the time needed to transport in 961 cases (81.7%) and overestimated in 121 (10.3%). Notably, 94 ETAs (8.0%) were accurate to within 1 min.

**Table 1. Comparison of Median Actual and EMS-Provided Estimated Time to Arrival**

| | n (%) | ETA, min (IQR) | ATA, min (IQR) | ATA-ETA, min (IQR) | Z-Statistic ($p$-value) |
|---|---|---|---|---|---|
| Overall | 1176 (100.0) | 5 (5–10) | 10 (7–12) | 3 (1–5) | 25.139 (< 0.001) |
| Subgroup | | | | | |
| Medical | 1011 (86.0) | 5 (5–8) | 9 (7–12) | 3 (1–5) | −23.411 (< 0.001) |
| Trauma | 165 (14.0) | 7 (5–10) | 10 (8–14.5) | 3 (1–6) | −9.210 (< 0.001) |
| MC | 74 (6.3) | 10 (5.75–12.5) | 12.5 (8–18.25) | 3 (1–6.125) | −5.962 (< 0.001) |
| Trauma activations | 20 (1.7) | 10 (6–14) | 13 (7.25–16.75) | 3 (1–3.875) | −3.026 (0.002) |
| ACS | 110 (9.3) | 5 (5–9.25) | 10 (7–13) | 4 (1–6) | −7.942 (< 0.001) |
| Stroke | 28 (2.4) | 8.75 (6–10) | 12 (9.25–15) | 2.5 (0.5–6) | −3.201 (0.001) |
| Cardiac arrest | 7 (0.6) | 5(4–10) | 10 (6–32) | 2 (1–22) | −2.226 (0.026) |

EMS = emergency medical services; ETA = estimated time to arrival; IQR = interquartile range; ATA = actual time to arrival; MC = medical command; ACS = acute coronary syndrome.

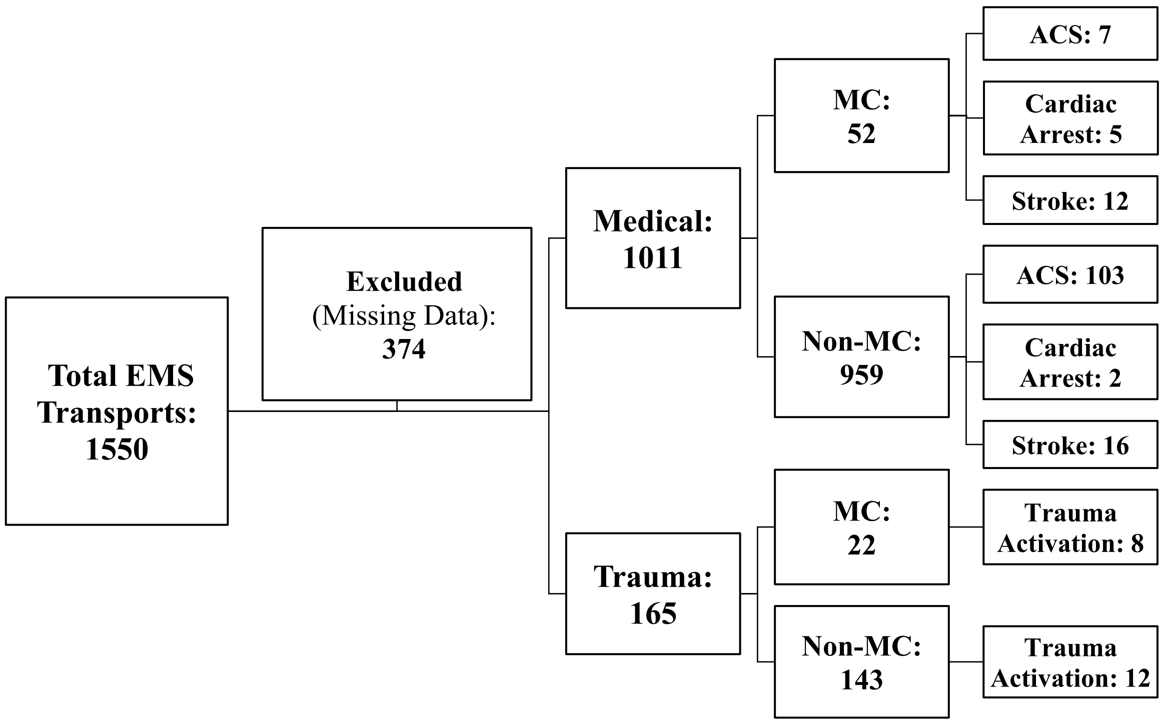


**Figure 1. Study flowchart.**
**ACS = acute coronary syndrome; MC = medical command; EMS, emergency medical services.**

Table 2. Comparison of Median Actual and EMS-Provided Estimated Time to Arrival by Month

| Month | n (%) | ETA, min (IQR) | ATA, min (IQR) | ATA-ETA, min (IQR) |
|---|---|---|---|---|
| August | 192 (16.3) | 5 (5–8.38) | 10 (7–14) | 4 (2–6.875) |
| December | 581 (49.4) | 5 (5–10) | 9 (7–12) | 3 (1–5) |
| January | 364 (31.0) | 5 (5–10) | 10 (7–12) | 3 (1–5) |
| February | 39 (3.3) | 5 (5–10) | 9 (7–11) | 2 (1–4) |

EMS = emergency medical services; ETA = estimated time to arrival; IQR = interquartile range; ATA = actual time to arrival.

A significant difference between ATA and ETA was observed in each of the other subgroups analyzed, apart from cardiac arrest ($p = 0.026$). Median differences ranged from a low of 2 min (IQR 1–22) in cardiac arrest ($Z = -2.226$, $p = 0.026$) to a high of 4 min (IQR 1–6) in ACS ($-7.942$, $p < 0.001$). Data and associated statistics are reported in Table 1. Box plots of ATA-ETA values by type of prehospital EMS call are depicted in Figure 2.

Significant differences in ATA-ETA were observed by month and time of day ($p = 0.002$, $p = 0.016$). The largest median difference between ATA and ETA was seen in August (4 min, IQR 2–6.875), and the smallest difference was observed in February (2 min, IQR 1–4). Baseline transport call characteristics were largely similar by month, allowing for the lower amount of data collected in February (Supplementary Table 1, available online). ETA data by month are reported in Table 2.

Significant differences in ATA-ETA were also observed by time of day ($p = 0.016$). The largest median difference was observed from 16:00–16:59 (5 min, IQR 2–7) and 07:00–07:59 (4.75 min, IQR 1–7). The smallest differences occurred from 06:00–06:59 and 09:00–09:59 (2 min, IQR 0.5–4 and 2 min, IQR 0.5–4.5). ETA data by time of day are reported in Table 3.

## Discussion

The study data demonstrate that EMS personnel are largely accurate in predicting the time of their arrival. Although teams consistently underestimated the time required to reach the ED in most ground transport cases (81.7%), the median difference was small at 3 min. This finding largely persisted regardless of the nature of the call

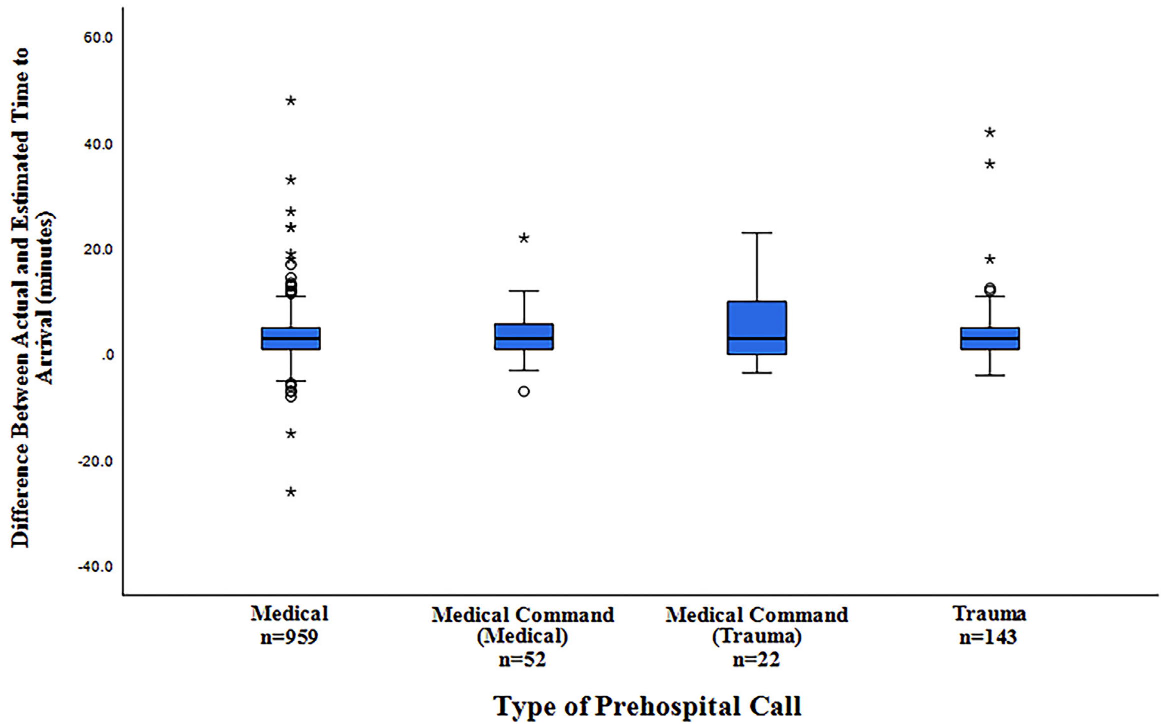


**Figure 2. Plots of difference between actual and estimated time of arrival by type of prehospital call.**

and reason for transport. These observations are strikingly similar to data reported by Propp and Rosenberg in 1991, in which 81.1% of transports were underestimated by a mean difference of 2.9 min (4).

Our study included all EMS ground transports and the small overall median difference in ATA-ETA we observed is unlikely to affect the usual workflow of ED personnel in the case of routine, noncritical patient transports. However, ATA-ETA differences could portend greater impact in more critical patients, such as trauma activations or cardiac arrests when more ED resources are pulled and duties are put on hold in anticipation of patient arrival. Holding multiple team members from their usual tasks likely represents a greater disruption to ED flow compared with EMS arrivals that are simply integrated into the active triage and bed assignment workflow.

In our cohort, subgroup analysis of trauma calls requesting medical command found a skew toward a greater degree of ETA underestimation compared with other types of calls. The median difference between ATA and ETA for trauma medical command calls was similar to nontrauma medical command calls and calls not requesting medical command; however, there was a larger density of trauma medical command call transports in which ETA underestimation was > 5 min. This finding is visually depicted in the box plots in Figure 2: the third quartile box and top whisker for trauma medical command call transports measures higher than those of the other call types. This observation, along with previous research identifying a median EMS ETA underestimation of 9 min in the transport of trauma activations, suggests that the magnitude of ETA underestimation may be greater among more severely injured trauma patients (5).

Our data identified two temporal peaks in ATA-ETA. Similar to Neeki et al., we found an ATA-ETA peak during the time interval 07:00–07:59; however, the greatest observed median ATA-ETA in our cohort occurred during 16:00–16:59 (5). We also identified a monthly ATA-ETA variability that parallels earlier research, with a nadir occurring in February and peak occurring in August (5).

Overall, our data suggest that current methods of determining ETA employed by prehospital personnel serves adequately for the ED transport population as a whole. We did not identify any systemic shortcomings indicating a need to reevaluate the general manner in which prehospital ETA are calculated for routine transports. However, our limited subgroup analysis suggests that there may be certain patient populations and clinical scenarios that could benefit from additional exploration with regards to EMS ETA and methods of improving accuracy. Future research might focus on identifying specific factors associated with greater magnitude of ETA inaccuracy and circumstances in which accurate EMS-provided ETA are most clinically important.

**Table 3. Comparison of Median Actual and EMS-Provided Estimated Time to Arrival by Time of Day**

| Time Interval | n (%) | ETA, min (IQR) | ATA, min (IQR) | ATA-ETA, min (IQR) |
|---|---|---|---|---|
| 00:00–00:59 | 37 (3.1) | 5 (5–10) | 10 (7–11.5) | 3.5 (2–5) |
| 01:00–01:59 | 24 (2.0) | 5 (5–7.5) | 8.5 (6–14.75) | 3 (1–5.75) |
| 02:00–02:59 | 26 (2.2) | 5 (5–10) | 9 (7.75–12.5) | 3.5 (1–6.25) |
| 03:00–03:59 | 38 (3.2) | 5 (5–8.25) | 9 (7–12) | 3 (1–5.25) |
| 04:00–04:59 | 45 (3.8) | 6 (5–10) | 11 (7.5–15) | 4 (1–6) |
| 05:00–05:59 | 30 (2.6) | 5 (5–7.75) | 8 (7–11.25) | 3 (1.375–5.25) |
| 06:00–06:59 | 23 (2.0) | 5 (5–7.5) | 8 (6–11) | 2 (0.5–4.5) |
| 07:00–07:59 | 42 (3.6) | 5 (5–7.13) | 10 (7–13.75) | 4.75 (1–7) |
| 08:00–08:59 | 66 (5.6) | 5 (5–10) | 9 (7–12) | 3 (1–5) |
| 09:00–09:59 | 55 (4.7) | 5.5 (5–10) | 9 (7–10) | 2 (0.5–4) |
| 10:00–10:59 | 66 (5.6) | 5 (5–10) | 9 (7–11) | 2.75 (0.75–5) |
| 11:00–11:59 | 58 (4.9) | 5.5 (5–10) | 8.5 (6–13) | 3 (1–4.125) |
| 12:00–12:59 | 56 (4.8) | 5 (5–10) | 10 (7–14.5) | 4 (2–6) |
| 13:00–13:59 | 64 (5.4) | 7.5 (5–10) | 10 (7–12) | 2.25 (0.125–4.375) |
| 14:00–14:59 | 62 (5.3) | 6 (5–8.63) | 10 (8–13) | 4 (1.375–6) |
| 15:00–15:59 | 56 (4.8) | 5 (4–7) | 10 (6.25–11) | 3.25 (1–5.75) |
| 16:00–16:59 | 63 (5.4) | 6 (5–10) | 11 (9–15) | 5 (2–7) |
| 17:00–17:59 | 74 (6.3) | 7 (5–10) | 10 (8–14) | 4 (0.75–6) |
| 18:00–18:59 | 76 (6.5) | 5 (5–10) | 9 (7–13.75) | 3 (1–5) |
| 19:00–19:59 | 51 (4.3) | 5 (5–7) | 10 (8–12) | 4 (2–6) |
| 20:00–20:59 | 49 (4.2) | 5 (5–7.25) | 9 (6–12) | 4 (1–6) |
| 21:00–21:59 | 40 (3.4) | 5 (5–10) | 9 (7.25–11.75) | 2.5 (0.0–4) |
| 22:00–22:59 | 36 (3.1) | 5 (5–10) | 10 (7.25–13) | 3 (1.625–6) |
| 23:00–23:59 | 39 (3.3) | 5 (5–8) | 9 (7–12) | 2.5 (1–6) |

EMS = emergency medical services; ETA = estimated time to arrival; IQR = interquartile range; ATA = actual time to arrival.

*Limitations*

There are limitations to the study that should be noted. Our study was performed at a single center and data were collected over 4 months. This may limit the generalizability of our findings. Study data collection was conducted only during the months of August, December, January, and February, which may have introduced bias; however, baseline demographics of transport calls were similar between months. Approximately 25% of eligible calls were excluded for missing data. Multiple ED staff members collected data and there could have been associated inconsistency. Relatively limited data were collected from certain subgroups, such as cardiac arrest, and the subgroup analysis is limited by small sample sizes.

The prehospital services included in the study did not use a standardized method for determining ETA, and the specific ways in which ETA was calculated were not assessed. Computerized Global Positioning System (GPS)-based navigation technology is widely available, but the extent of its use by EMS providers during the study period is unclear. Only a few studies have addressed the utility of GPS in improving EMS-provided ETA predictions, and this represents a potential area of future research (7,8).

We observed a statistically significant difference between ETA and ATA; however, this may not represent a clinically significant finding. For example, the median ATA-ETA difference of 3 min could reflect the amount of time needed to offload the patient from the ambulance, move the stretcher into the ED, and initiate registration. EMS providers may not have considered these extra few minutes of ambulance-to-ED patient relocation time when calculating their ETA.

## Conclusion

Our data demonstrate that prehospital providers underestimate time to ED arrival in most ground transports; however, the median difference between estimate and actual time to arrival is small. Future research should examine prehospital ETA accuracy in different practice settings and specific patient populations.

## Declaration of competing interest

None.

## Acknowledgment

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## Supplementary Materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jemermed.2023.12.010.

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## Article Summary

**1. Why is this topic important?**

Emergency medical services (EMS)-provided estimated time to arrival (ETA) are important for efficient emergency department (ED) operations, yet clinical anecdote suggests that such estimates may be lacking in accuracy. There has been relatively little recent published quantitative research assessing the accuracy of ETA currently provided by EMS patient transport units arriving to the ED.

**2. What does this study attempt to show?**

This study compares EMS-provided ETA to actual time to arrival in all ground unit transports to a single ED. Overall ETA accuracy was assessed, as well as accuracy of ETA in subgroups defined by the type of call, type of patient, time of day, and month of the year.

**3. What are the key findings?**

Our data demonstrate that prehospital providers underestimate time to ED arrival in most ground transports; however, the median difference between estimate and actual time to arrival is small.

**4. How is patient care impacted?**

Our study results demonstrate that current EMS methods of determining ETA are likely adequate for routine patient transports; however, subgroup analysis suggests that ETA for the transport of more critical trauma patients may benefit from further optimization.