Open Access Emergency Medicine Dovepress

Open Access Full Text Article

ORIGINAL RESEARCH

Traffic Patterns and Emergency Medical Services Prenotification Transport Estimates in Trauma Activations

Sophia Gorgens[1], Ella R Rastegar[2,3], Manuel Beltran del Rio[3], Cristy Meyer[3], Daniel M Rolston[1,4], Maria Sfakianos[3,4], Eric N Klein[3,4], Timmy Li[1,4], Rashmeet Gujral[1,4], Matthew A Bank[3,4], Daniel Jafari[1,4]

[1]Department of Emergency Medicine, Northwell Health, Long Island, NY, USA; [2]Albert Einstein College of Medicine, Bronx, NY, USA; [3]Department of Surgery, Northwell Health, Long Island, NY, USA; [4]Zucker School of Medicine at Hofstra, Long Island, NY, USA

Correspondence: Sophia Gorgens, Department of Emergency Medicine, Northwell Health, 300 Community Drive, Manhasset, NY, 11030, USA, Email sophia.gorgens@gmail.com

Objective: To determine whether traffic patterns affect the accuracy of emergency medical services (EMS) prediction of transport interval to the emergency department (ED).

Methods: Using a retrospective study, we examined all trauma activations at a level one, urban trauma center in Manhasset, New York, between 5/22/2021 and 3/30/2022. Inclusion criteria included patients ≥18 years and arrival by EMS. Field trauma activations involve prenotification communication through a government intermediary. Transport during “peak hours” was defined as hospital arrival of EMS between 06:00–10:00 and 16:00–20:00, Monday through Friday. ETI and actual transit interval (ATI) were extracted from the recorded prenotification calls and hospital records respectively. In instances with a time range, the arithmetic mean was used. ATI was defined as the time from prenotification call to arrival at the hospital. A 25% difference between EMS ETI and ATI was chosen to categorize each arrival as overestimated (ATI/ETI < 0.75), accurate (ATI/ETI within 0.75–1.25), and underestimated (ATI/ETI > 1.25). Fisher’s exact and Wilcoxon Rank Sum tests were used for comparative analysis as appropriate.

Results: Of the 369 trauma transports, 117 had prenotification reports with an ETI and were included in our analysis. Of those, 29 (25%) occurred during peak hours. Overall, EMS more often underestimated ETI (55%) than exactly (32%), or overestimated ETI (12%) ($p<0.0001$). This was true during peak and off-peak hours with underestimated, accurate, and overestimated arrivals being 59%, 31%, 10% ($p<0.01$); and 54%, 33%, 12% ($p<0.001$), respectively. There was no statistically significant difference between peak vs off-peak hours when comparing the proportion of under vs over-estimated times of arrival ($p=0.263$).

Conclusion: While our hypothesis was not borne out, further research on the antecedents of underestimated transport intervals in traumas is warranted. This will allow for targeted solutions to best support EMS clinicians in communicating transport times back to the ED.

Keywords: prehospital communication, telecommunication, trauma notification, transport time, prehospital notification

Introduction

As one of the leading causes of death in the United States, trauma presents a unique challenge to emergency departments (ED). While many traumas are over-triaged in the field, critically ill patients often require substantial care and significant resources and the initial management of trauma patients is crucial to patient outcomes.[1] When assessing how to optimize the initial management of trauma patients, most research focuses on the emergency medical services (EMS) to provider handoff, on Advanced Trauma Life Support (ATLS), and on running an efficient trauma resuscitation.[2–6] Goldberg et al analyzed the qualitative handoff for critically ill patients between EMS and the ED and found that many handoffs missed crucial information such as vital signs, pertinent physical exam findings, and even chief complaint.[2] Other studies, such as the work by Maddry et al, demonstrated the efficacy of using a standardized patient hand-off tool[3] while Verhoeff et al

Received: 27 May 2024
Accepted: 20 November 2024
Published: 29 November 2024

focused on improving trauma team activation by root-cause analysis and quality improvement interventions.[6] While this body of literature is crucial in improving patient care and communication between the prehospital and hospital setting, there is limited data concerning the effect transport time, from scene to arrival at the hospital, on mortality.[7,8] Synnot et al did a recent systemic review examining prehospital notification for major trauma patients and found only three observational studies to include in the review, which limited any conclusive evidence of the impact prenotifications might have on patient outcomes.[7] Waalwijk et al looked particularly at the impact of total prehospital time, on-scene time, and transport time on patient mortality with mixed results – although longer total time and transport time did not increase mortality, longer on-scene times did.[8]

Clear, accurate communication between emergency medical service (EMS) clinicians and emergency department (ED) personnel about trauma transport intervals should improve patient welfare, conserve hospital resources, and improve EMS/ED teamwork. However, prior studies have characterized discrepancies between the estimated time to arrival (ETT) and actual time to arrival (ATA) of trauma patients by EMS, but the root cause of this discrepancy remains unknown.[9–13] The study by Wallace et al in particular reviewed transport time estimates and compared it to observed transport times, noting a moderate accuracy about 87% of the time.[12] Outside of speculation, they were unable to account, however, for the cases where the estimated and observed transport time did not align.[12] Other studies run into a similar issue – identifying the problem of discrepancies between estimated and observed transport times without identifying the cause.

EMS clinicians need meaningful, systemic support to communicate an accurate estimated transit interval (ETI) back to the ED. To provide that support, however, researchers must first zero in on the underlying cause of ETI discrepancies.

Prenotification allows trauma centers to activate their trauma teams and prepare for patient arrival. Each trauma activation consumes resources and diverts physician and staff attention from caring for other patients.[9] When EDs are not given a prenotification call, the result can be hectic, leading to a suboptimal ATLS code and a degradation in patient care.[14,15] However, if the prenotification call underestimates the arrival interval, resources are tied up in waiting longer than needed and care of existing patients is delayed.

Road traffic may cause EMS clinicians difficulty in accurately estimating trauma transport intervals, but there is limited data to support this claim. Attempts to improve prenotification reliability with adjuncts such as Citizen App, street networks, Google Maps, and global positioning systems (GPS) have had only moderate success.[15,16] For example, Fleischman et al did a retrospective study using Google Maps and various call characteristics (including weather, patient characteristics, and the use of lights and sirens) to create a model for accurate transport times.[16] They then compared the modeled transport times to the actual transport times and found that their model was accurate (within 5 minutes) 73% of the time.[16] However, this still means that 27% of calls were not accurately modeled.

To better understand the overall accuracy of ETI at our hospital as well as the role of traffic in discrepancies between ETI and ATI, we analyzed EMS transport interval data for trauma patients during all traffic hours. We hypothesized that ETI in off-peak traffic hours would be more accurate than ETI in peak traffic hours in trauma patients transported by EMS to the hospital.

Methods

To assess the effect of traffic on trauma patients transported by EMS, we conducted a retrospective review of all trauma activations at North Shore University Hospital, an urban, adult, level one trauma center, over ten months. The Institutional Review Board reviewed and approved the study under exempt status.

Sample Size

Per local EMS protocols, field trauma activations involve prenotification communication through a government intermediary that is audio-recorded for quality improvement. For this study, we reviewed all recorded EMS communications to an urban, adult, level one trauma center for level 1 and level 2 trauma activations between 5/22/2021 and 3/30/2022. The sample size was chosen for convenience. Inclusion criteria was patients ≥18 years and arrival by EMS. Exclusion criteria included lack of a prenotification call or unavailable recording of ETI. Transport during "peak hours" was defined as hospital arrival of EMS between 06:00–10:00 and 16:00–20:00, Monday through Friday. "Off-peak hours" were defined as all other times. These time frames were chosen based on local traffic patterns.

Statistical Analysis

ETI and ATI were extracted from the recorded calls. The data was abstracted by a single investigator (ER), who was trained on other prenotification calls by an experienced trauma program coordinator (CM), who had over 100 data abstractions before this study. In instances in which ETI was provided as an approximate window, the arithmetic mean was used (ie, ETI of "six to ten minutes" was recorded as eight minutes). ATI was defined as the time from prenotification call to arrival at the hospital based on the electronic medical record. A 25% difference in ATI to ETI ratios was chosen to categorize each arrival as "overestimated" (ratio ATI to ETI < 0.75), "accurate" (ratio within 0.75–1.25), and "underestimated" (ratio > 1.25). This was chosen as the authors felt that 25% inaccuracy in estimates are reasonable and would not negatively impact the trauma team. Proportions were compared using Fisher's exact test. Paired ETI vs ATI comparisons were done through a Wilcoxon Rank Sum test. P values <0.05 were considered statistically significant. All calculations, database manipulation, tables and figures were done using PythonTM3 software in conjunction with SciPy[17] and PANDAS.[18]

Results

There were 369 trauma transports during the study period, 117 of which had prenotification reports with an ETI and were included in our analysis. Of those, 29 (25%) occurred during peak hours. Overall, EMS clinicians underestimated their transit interval more than they correctly estimated it, with a median difference of 2 minutes (interquartile range –1 and 5 minutes), as demonstrated in Figure 1. Most arrival times were underestimated (65, 55%), rather than accurate (38, 32%) or overestimated (14, 12%). In 68% of cases ETI was shorter than ATI (p<0.01). This was true during peak and off-peak hours with underestimated, accurate, and overestimated transit intervals of 59%, 31%, 10% (76% ETI<ATI, p<0.01); and 54%, 33%, 12% (63% ETI, p<0.01), respectively (Table 1). There was no statistically significant difference between peak (7 out of 22, 32%) vs off-peak hours (32 out of 56, 57%) when comparing the proportion of under- vs overestimated transport times (p=0.263) (Figure 2).

These results build onto the existing evidence of research that EMS estimated transport times are often inaccurate compared to actual times. A study by Neeki et al similarly examined the accuracy of estimated to actual transport time for EMS in San Bernardino County, California.[9] They found that EMS underestimated transport time by a median of 9 minutes, which is a larger discrepancy than found in our study.[9] While month and time of day was associated with variability in the median discrepancy between estimated and actual transport time, the authors were not able to show

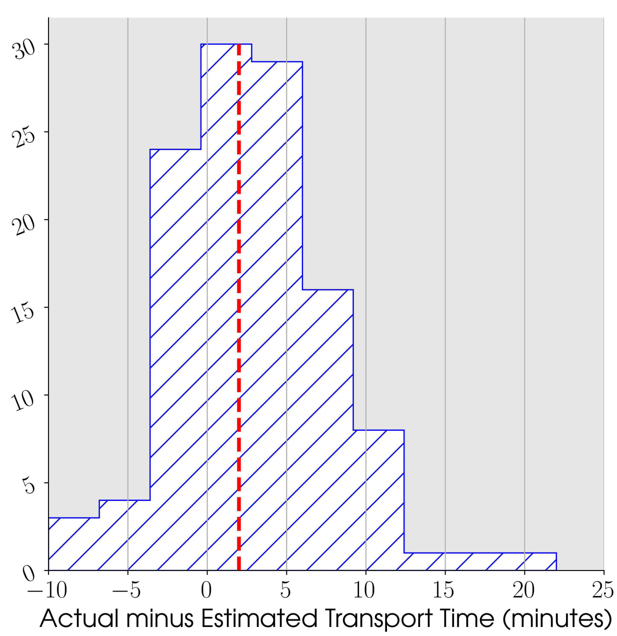

Figure 1 Histogram of actual transport interval in minutes minus estimated transport interval. Median marked in red.

https://doi.org/10.2147/OAEM.S480081

Table 1 Emergency Medical Services Estimated Transport Interval (ETI) Vs Actual Transport Interval (ATI) Differences Categorized as "Early" (Ratio ATI to ETI < 0.75), "on Time" (Ratio Within 0.75–1.25), and "Late" (Ratio > 1.25), Divided by Peak Vs off-Peak Hours (*p<0.01)

		Overall N=117	Off-Peak N=88	Peak N=29
Lateness (N/% ETA<ATA)		78 (67%)*	56 (63%)*	22 (76%)*
Accuracy (% In-zone)	Late	65 (55%)	48 (54%)	17 (59%)
	On-Time	38 (32%)	29 (33%)	9 (31%)
	Early	14 (12%)	11 (12%)	3 (10%)

a clear link between traffic patterns or other factors that might explain this variability.[9] In our study, we specifically examined peak and off-peak traffic hours and did not find a significant difference between the two.

Discussion

In our study, we found that regardless of off-peak or peak traffic times, EMS underestimated their transport times in more than 50% of calls. EMS estimates were only accurate in 31–33% of the cases and overestimated transport times in 10–12% of the cases. While our results are from an urban setting, we believe the results have important implications for other settings including internationally. The study by Neeki et al similarly in San Bernardino County, California is one of the few studies with similar methodology and used data from over ten years ago in a different setting – and yet still found similar results regarding the inaccuracy of EMS transport time estimates.[9] This

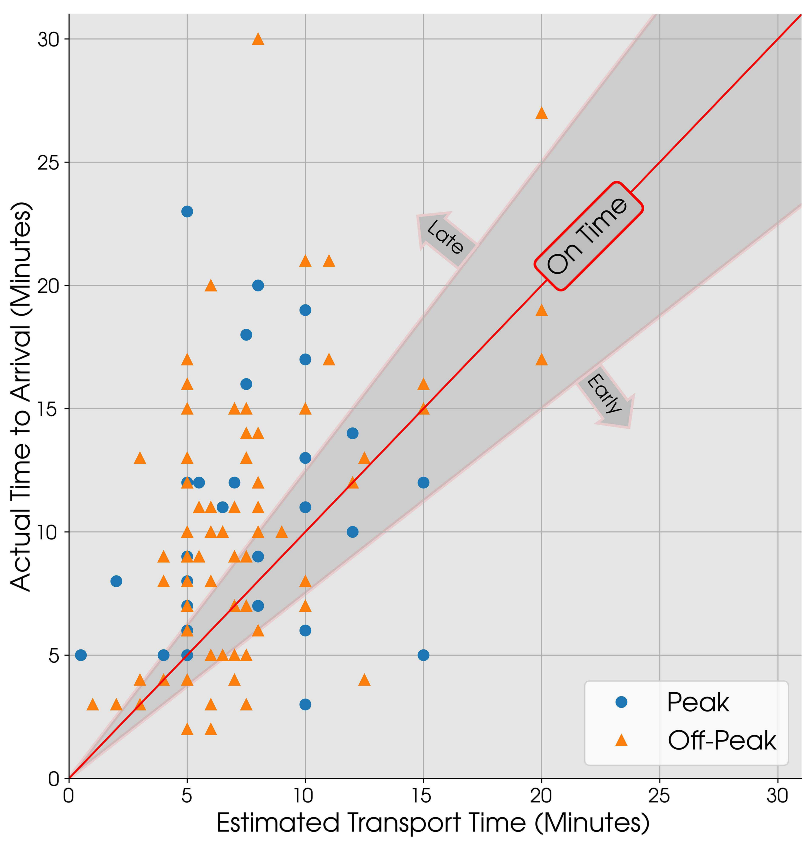

Figure 2 EMS estimated transport interval (ETI)(also called estimated transport time) in minutes versus actual transport interval (ATI) (also called actual time to arrival) (n = 117). The red line indicates where accurate estimates would fall.

emphasizes the pervasiveness of the issue and the difficulty of getting accurate transport time estimates. Since traffic congestion is a persistent challenge across the globe in all metropolitan areas, there is a widespread perception that the inaccuracies in ETI by EMS is at least partly explained by traffic. However, our results do not support this, showing no correlation between time of day (off-peak versus peak) and inaccuracies in ETI. If traffic patterns cannot be blamed, then it is unclear what is causing this discrepancy between ETI and ATI. Unless further data do show a correlation with traffic, EMS in large cities should consider alternative solutions to mitigate their ETI accuracy. It may be that each EMS system faces a variety of different reasons for inaccurate ETIs, from the GPS software that EMS clinicians use to protocols around siren use to individual driving practices and city culture. A broader, national review of data would be needed to assess for this. If the reasons for inaccurate estimates vary, alternative solutions would have to be tailored to the EMS system.

While in our study, we found that ETI/ATI discrepancy is not associated with peak traffic hours, it may be that traffic does affect ETI in other parts of the country. However, given that our study found that EMS clinicians tended to underestimate ATI across the board, future work should attempt both to elucidate the antecedents of underestimated transport intervals and to determine its effects. At present, it is unclear whether estimated transport interval discrepancies affect trauma patient morbidity or mortality; whether they affect the care of other patients in the ED at the time of prenotification; and whether they affect interdisciplinary teamwork, especially between EMS clinicians and ED personnel. A study by Waalwijk et al demonstrated that while transport time itself did not increase morbidity and mortality in trauma patients, prolonged scene time did.[8] Few additional studies have been done in this area of research, so evidence remains scarce as to how much and to what extent transport time might affect trauma patient morbidity and mortality. While other studies have focused on quality improvement outcomes for trauma team activations and the effect of prehospital notifications on trauma patient outcomes, the effect of prehospital notifications on trauma team activations and on other, non-trauma patients in the hospital remain unknown.[6,7]

Only by identifying possible causes of this discrepancy can we improve EMS/ED transport interval communication. Many EMS systems do not have the ability to communicate directly with EDs, instead reporting their transit estimate to a third-party dispatch center. Allowing for direct communication between EMS and EDs may further improve the accuracy of estimated transit intervals Working with navigation phone apps or equipping ambulances with GPS are two possible avenues of creating a system where ambulance crews could automatically and securely send their estimated time to arrival to trauma centers.

Our results suggest a need for innovative solutions to help EMS clinicians, who are dealing with unprecedented staffing shortages and task loading during transport, accurately communicate their estimated transit interval to ED personnel. Further research should look at a larger sample of EMS systems to focus on identifying the impact of transit interval over- and under-estimation on trauma patients, as well as its causes and potential solutions.

Limitations

Our study had several limitations. Of the 369 trauma transports, 117 had prenotification reports with an ETI and were included in our analysis – the missing data from the prenotifications that did not include an ETI might affect results. Future work should reinforce to EMS personnel the importance of including an ETI to help hospitals better prepare for incoming trauma patients. Moreover, as we did not measure actual traffic patterns during the timeframe of our study, we cannot confirm that our definition of "peak" versus "off-peak" hours closely matched times of highest actual traffic activity. The data analyzed came from a single level 1 trauma center in an urban environment. Other trauma centers in different cities or environments may be impacted by traffic to a greater or lesser extent. While certain aspects of EMS training are standardized and universal, each EMS system is unique – local differences in training, management, and work culture may also affect results. Finally, it is unknown if the EMS personnel in our data were using any GPS assistance in estimating their arrival time or estimating based on their own predictions of traffic. EMS systems that have integrated GPS when reporting their ETI might therefore have different results.

Conclusion

When comparing ETI to ATI, we found that EMS underestimated their transport interval more than 50% of the time, regardless of arrival during off-peak vs peak hours. This discrepancy can be detrimental to patient care if it causes delays in care or poor allocation of resources. Future studies are needed to explore the use of technology to help EMS more accurately estimate arrival times.

Data Sharing Statement

The data and detailed analysis plan are available upon request. Please contact the Corresponding Author.

Funding

There is no funding to report.

Disclosure

Dr Daniel Rolston reports grants from Flosonics Medical, outside the submitted work. The authors report no other conflicts of interest in this work.

References

1. Voskens FJ, van Rein EAJ, van der Sluijs R, et al. Accuracy of prehospital triage in selecting severely injured trauma patients. *JAMA Surg*. 2018;153(4):322–327. doi:10.1001/jamasurg.2017.4472
2. Goldberg SA, Porat A, Strother CG, et al. Quantitative analysis of the content of EMS handoff of critically ill and injured patients to the Emergency Department. *Prehosp Emerg Care*. 2017;21(1):14–17. doi:10.1080/10903127.2016.1194930
3. Maddry JK, Simon EM, Reeves LK, et al. Impact of a standardized patient hand-off tool on communication between Emergency Medical Services personnel and Emergency Department staff. *Prehosp Emerg Care*. 2021;25(4):530–538. doi:10.1080/10903127.2020.1808745
4. Kool DR, Blickman JG. Advanced trauma life support. ABCDE from a radiological point of view. *Emerg Radiol*. 2007;14(3):135–141. doi:10.1007/s10140-007-0633-x
5. Mohammad A, Branicki F, Abu-Zidan FM. Educational and clinical impact of Advanced Trauma Life Support (ATLS) courses: a systematic review. *World J Surg*. 2014;38(2):322–329. doi:10.1007/s00268-013-2294-0
6. Verhoeff K, Saybel R, Fawcett V, Tsang B, Mathura P, Widder S. A quality-improvement approach to effective trauma team activation. *Can J Surg*. 2019;62(5):305–314. doi:10.1503/cjs.000218
7. Synnot A, Karlsson A, Brichko L, et al. Prehospital notification for major trauma patients requiring emergency hospital transport: a systematic review. *J Evid Based Med*. 2017;10(3):212–221. doi:10.1111/jebm.12256
8. Waalwijk JF, van der Sluijs R, Lokerman RD, et al. The impact of prehospital time intervals on mortality in moderately and severely injured patients. *J Trauma Acute Care Surg*. 2022;92(3):520–527. doi:10.1097/TA.0000000000003380
9. Neeki MM, MacNeil C, Toy J, et al. Accuracy of perceived estimated travel time by EMS to a trauma center in San Bernardino County, California. *West J Emerg Med*. 2016;17(4):418–426. doi:10.5811/westjem.2016.5.29809
10. James MK, Clarke LA, Simpson RM, et al. Accuracy of pre-hospital trauma notification calls. *Am J Emerg Med*. 2019;37(4):620–626. doi:10.1016/j.ajem.2018.06.058
11. Maris M, Berben SAA, Verhoef W, van Grunsven P, Tan ECTH. The quality of pre-announcement communication and the accuracy of estimated arrival time in critically ill patients, a prospective observational study. *BMC Emerg Med*. 2022;22(1):44. doi:10.1186/s12873-022-00601-z
12. Wallace DJ, Kahn JM, Angus DC, et al. Accuracy of prehospital transport time estimation. *Acad Emerg Med*. 2014;21(1):9–16. doi:10.1111/acem.12289
13. Ahmed OZ, Yang S, Farneth RA, Sarcevic A, Marsic I, Burd RS. Association between prearrival notification time and advanced trauma life support protocol adherence. *J Surg Res*. 2019;242:231–238. doi:10.1016/j.jss.2019.03.032
14. Lillebo B, Seim A, Vinjevoll OP, Uleberg O. What is optimal timing for trauma team alerts? A retrospective observational study of alert timing effects on the initial management of trauma patients. *J Multidiscip Healthc*. 2012;5:207–213. doi:10.2147/JMDH.S33740
15. Kelly GS, Clare D. Improving out-of-hospital notification in traumatic cardiac arrests with novel usage of smartphone application. *J Am Coll Emerg Physicians Open*. 2020;1(4):618–623. doi:10.1002/emp2.12146
16. Fleischman RJ, Lundquist M, Jui J, Newgard CD, Warden C. Predicting ambulance time of arrival to the emergency department using global positioning system and Google maps. *Prehosp Emerg Care*. 2013;17(4):458–465. doi:10.3109/10903127.2013.811562
17. Virtanen P, Gommers R, Oliphant TE; SciPy1.0 Contributors, et al. SciPy 1.0: fundamental algorithms for scientific computing in Python. *Nature Methods*. 17;2020:261–272. doi:10.1038/s41592-019-0686-2
18. McKinney W . Data structures for statistical computing in python. In: van der Walt S, Millman J, editors. Proceedings of the 9th Python in Science Conference; 2010; Austin, TX: 51–56.