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Not All Prehospital Time is Equal: Influence of Scene Time on Mortality

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Abstract

Background—Trauma is time-sensitive and minimizing prehospital (PH) time is appealing. However, most studies have not linked increasing PH time with worse outcomes, as raw PH times are highly variable. It is unclear whether specific PH time patterns affect outcomes. Our objective was to evaluate the association of PH time interval distribution with mortality.

Methods—Patients transported by EMS in the Pennsylvania trauma registry 2000-2013 with total prehospital time (TPT)≥20min were included. TPT was divided into three PH time intervals: response, scene, and transport time. The number of minutes in each PH time interval was divided by TPT to determine the relative proportion each interval contributed to TPT. A prolonged interval was defined as any one PH interval contributing ≥50% of TPT. Patients were classified by prolonged PH interval or no prolonged PH interval (all intervals<50% of TPT). Patients were matched for TPT and conditional logistic regression determined the association of mortality with PH time pattern, controlling for confounders. PH interventions were explored as potential mediators, and prehospital triage criteria used identify patients with time-sensitive injuries.

Results—There were 164,471 patients included. Patients with prolonged scene time had increased odds of mortality (OR 1.21; 95%CI 1.02–1.44, p=0.03). Prolonged response, transport, and no prolonged interval were not associated with mortality. When adjusting for mediators

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including extrication and PH intubation, prolonged scene time was no longer associated with mortality (OR 1.06; 0.90–1.25, p=0.50). Together these factors mediated 61% of the effect between prolonged scene time and mortality. Mortality remained associated with prolonged scene time in patients with hypotension, penetrating injury, and flail chest.

Conclusions—Prolonged scene time is associated with increased mortality. PH interventions partially mediate this association. Further study should evaluate whether these interventions drive increased mortality because they prolong scene time or by another mechanism, as reducing scene time may be a target for intervention.

Level of Evidence—IV, prognostic study

Keywords

Outcome; Prehospital time; Emergency medical services; Intubation; Extrication

BACKGROUND

Trauma is a time-sensitive disease. It follows that minimizing prehospital (PH) time is potentially beneficial to outcomes.[1] Total prehospital time (TPT) can be divided into response, scene, and transport intervals. Each interval requires a different approach to minimize time, and some intervals are more amenable to modification. Response time includes time from emergency medical services (EMS) notification to arrival at the scene of injury. Reduction in this interval requires increasing the number of EMS units available and optimal configuration for service area coverage. Scene time includes time from arrival at the scene to the time EMS leaves for the hospital. This interval may be most actionable, and reduction may involve limiting interventions provided on scene. This has led to the concept of “scoop and run” for the injured patient.[2] In this approach, EMS transports the patient as rapidly as safely possible, providing minimal or no interventions in the field. Finally, transport time includes time from leaving the scene until arrival at the hospital. As this PH interval is largely determined by distance from the scene to the hospital, reduction in transport time generally would require a faster transport mode, such as helicopter, when appropriate.[3]

However, most studies have failed to link increasing PH time with worse outcomes.[4–9] This may be due to heterogeneity among patients as well as characteristics of the trauma and EMS systems studied. Further, raw PH times are highly variable depending on several factors including traffic, weather, geography, EMS system configuration, and transport mode.[10] It remains unclear whether a specific pattern of PH time may impact outcome. An evaluation of PH time interval distribution may yield insight into whether prolongation of one PH time interval in relation to others is associated with adverse outcome, and thus represents a potential target for intervention.

Our objective was to evaluate the association of specific PH time patterns with mortality, as well as potential mediators of these associations that may be modifiable in the context of PH trauma care. We hypothesized that at least one prolonged PH time interval would be

associated with mortality and that specific PH factors would be identifiable that partially mediate that association.

METHODS

Study Population

All patients ≥16 years transported by EMS with a TPT ≥20min in the Pennsylvania trauma registry between January 1st, 2000 and June 30th, 2013 were eligible for inclusion. The Pennsylvania trauma registry collected data from 36 trauma centers over the study period, which was mandatory for accreditation as a trauma center.

Patients transferred from another hospital, with burn injury, or those not transported by EMS were excluded. Patients were also excluded if PH time interval data were missing. Demographics, comorbidities, prehospital care, injury characteristics, vital signs, *International Classification of Diseases, Ninth Revision* (ICD-9) diagnosis codes, procedures, complications, and outcomes were collected.

Missing Data

Multiple imputation was performed for variables missing <25% of observations. Imputed variables included race, insurance status, injury severity score (ISS), PH systolic blood pressure (SBP), PH heart rate (HR), PH crystalloid volume, admission SBP, admission HR, and blood received in the emergency department (ED). Multiple imputation using chained equations was performed to develop five imputed datasets. Outcome models combined coefficients and standard errors from each imputed dataset while adjusting for the variability between imputed datasets.[11] Missing data for imputed variables ranged from 1% (ISS, admission HR) to 11% (PH crystalloid volume). Sensitivity analyses with complete cases were performed and similar results were seen, thus results from imputed data are presented below.

Prehospital Time

Total prehospital time was divided into three intervals: response, scene, and transport time. To evaluate the association of PH time patterns with outcome, the relative proportion of TPT was determined for each interval. The number of minutes in each interval was divided by TPT minutes to obtain the relative proportion each interval contributed to TPT. Based on the relative proportions of each PH time interval, patients were then classified as having a prolonged PH time interval, defined as one PH time interval contributing ≥50% of TPT, or no prolonged PH time interval defined as all PH time intervals <50% of TPT. Binary variables were created indicating presence or absence of four possible PH time patterns: prolonged response time, prolonged scene time, prolonged transport time, and no prolonged PH time interval.

To ensure patients compared across PH time patterns had similar TPT, patients were divided into TPT blocks. Patients were sorted by TPT and sequential blocks of 25 patients created. Patients with the same TPT were randomly sorted. Final analysis was performed for patients within these TPT blocks to minimize any differences in TPT among patients.

Statistical Analysis

The primary outcome was in-hospital mortality. A risk-adjustment model was developed, controlling for age, sex, race, insurance, comorbidities, mechanism, transport mode (helicopter versus ground), prehospital provider level (advanced versus basic life support), PH crystalloid volume, prehospital and admission vital signs, ISS, severe head injury (head AIS≥3), blood transfused in the ED, surgery for hemorrhage or craniotomy within 24hours, and complications. Robust variance estimators were used to account for clustering at the center-level. This risk-adjustment model was applied as conditional logistic regression models to evaluate the association of each PH time pattern with mortality within TPT blocks. Fitted regression lines were used to examine whether the relationship between mortality rate and continuous PH time intervals differed across the length of other PH time intervals.

For each PH time interval significantly associated with mortality, prehospital variables were explored as potential mediators.[12] Risk-adjustment models were repeated including potential mediators to evaluate the association of mediators with mortality as well as whether the association between prolonged PH time interval and mortality was significantly attenuated. Proportion of the total effect between prolonged PH time interval and mortality that was mediated by these variables was determined from casual mediation analysis.[13]

The presence of national field triage guidelines criteria were determined for each patient.[14] The national field triage criteria are organized into four sequential steps, including physiologic (SBP<90mmHg, RR<10 or >29bpm, GCS≤13), anatomic (penetrating injury, flail chest, open skull fracture, ≥2 proximal long bone fractures, pelvic fracture, crush injury, amputation, paralysis), mechanism (fall≥20feet, motorcycle crash, vehicle versus pedestrian), and special consideration criteria (age>55, anticoagulation). Patients were stratified by presence of these criteria and the risk-adjustment model was applied in each triage criterion subgroup to determine if any of these criteria can identify patients in the field for whom a prolonged PH time interval is associated with mortality. Mediators identified were also added to the triage subgroup models to determine if a prolonged PH time interval remained associated with mortality when controlling for mediators within triage criterion subgroups. False discovery rate correction was used to account for multiple comparisons.[15] For these models, q values are reported which represent false discovery rate adjusted p values and can be interpreted similarly to standard p values, with significance defined as q≤0.05.

Continuous data are presented as median (interquartile range [IQR]). Continuous variables were compared using Wilcoxon rank-sum tests, and categorical variables compared using Chi-squared tests. Adjusted odds ratios (AOR) and 95% confidence intervals (95%CI) were obtained for model variables. To assess risk-adjustment model performance, the model was applied as a logistic model to the entire study population with evaluation of the c-statistic and calibration curves. A two-sided p value ≤0.05 was considered significant. Data analysis was conducted using Stata v13MP (StataCorp; College Station, TX).

RESULTS

A total of 164,471 patients were included (Fig. 1). Most patients did not have a prolonged PH time interval. Among patients with a prolonged PH time interval, prolonged transport time was most common, followed by prolonged scene time, and prolonged response time.

Unadjusted patient characteristics by PH time pattern groups are shown in Table 1. The risk-adjustment model demonstrated excellent performance with a c-statistic of 0.94 and difference between observed and predicted mortality <0.2% across predicted risk deciles.

Regression revealed a prolonged scene time was independently associated a 21% increase in odds of mortality after controlling for confounders (AOR 1.21; 95%CI 1.02–1.44, p=0.03). Mortality was not associated with no prolonged PH time interval (AOR 0.98; 95%CI 0.76—1.24, p=0.84), prolonged response time (AOR 1.16; 95%CI 0.83—1.63, p=0.38), or prolonged transport time (AOR 0.82; 95%CI 0.65—1.04, p=0.11).

Similar results were seen when evaluating blunt and penetrating patients separately. Prolonged scene time was associated with increased mortality in both blunt (AOR 1.20; 95%CI 1.01—1.44, p=0.04) and penetrating patients (AOR 1.59; 95%CI 1.29—1.97, p<0.01), while, prolonged response time, prolonged transport time, and no prolonged PH time interval were not associated with mortality (p>0.05).

When evaluating the relationship between scene time and mortality across other PH time intervals, response time and transport time were combined into a single travel time interval. Mortality was plotted against scene time for each quintile of travel time. Quadratic regression lines demonstrated the best fit for mortality and scene time across travel time quantiles, with r^2 values ranging from 0.32 to 0.84 (Fig 3). The first and second travel time quantiles initially have an inverse relationship between mortality and scene time with inflections at 26min and 14mins respectively, after which increasing scene time is associated with increasing mortality. Longer travel times over the remaining quantiles demonstrate a direct relationship with mortality across all scene time values. This suggests at low travel times, the detrimental impact of increased scene time is lower; however, as travel time increases, the deleterious impact of increasing scene time becomes more pronounced.

For prolonged scene time, need for extrication and PH intubation were identified as potential mediators. Extrication was significantly higher in patients with prolonged scene time compared to those without prolonged scene time (21.5% versus 13.6%, p<0.01), as was PH intubation (8.1% versus 4.6%, p<0.01). Regression revealed that scene time was extended by 4min 30seconds due to extrication and by 6min 22second due to intubation on average.

When adding extrication to the risk-adjustment model, prolonged scene time was no longer associated with mortality (AOR 1.16; 95%CI 0.97—1.38, p=0.06) while extrication was (AOR 1.40; 95%CI 1.19—1.65, p<0.01). Adding PH intubation to the model also abolished the association between prolonged scene time and mortality (AOR 1.09; 95%CI 0.92—1.29, p=0.32) while PH intubation was associated with increased odds of mortality (AOR 4.49; 95%CI 3.48—5.78, p<0.01). Figure 2 demonstrates adding both extrication and PH intubation to the model further attenuated the relationship between prolonged scene time and

mortality (AOR 1.06; 95%CI 0.90—1.25, p=0.50) while both mediators remained associated with mortality (extrication AOR 1.46; 95%CI 1.23—1.72, p<0.01, PH intubation AOR 4.53; 95%CI 3.52—5.82, p<0.01). Extrication mediated 13.7% (95%CI 12.1%–14.3%) of the effect between prolonged scene time and mortality, while PH intubation mediated 51.2% (95%CI 45.0%–63.5%), and both together mediated 60.5% (95%CI 53.5%—73.4%) of the total effect. Finally, when analyzing only patients that did not undergo extrication or PH intubation, prolonged scene time was not associated with mortality (AOR 1.10; 95%CI 0.89—1.36, p=0.37).

To further evaluate the effect of extrication and PH intubation on outcomes, the average annual volume of extrications and PH intubations were calculated at the EMS agency level. The median number of annual extrications across EMS agencies was 0.43 (range 0, 49). Each additional 10 extrications at the EMS agency level was associated with an 11% decrease in odds of mortality in the risk-adjustment model (AOR 0.89, 95%CI 0.79—0.99, p=0.04). Linear regression demonstrated that each additional 10 extrications at the EMS agency level was associated with a 31second decrease in scene time when adjusted for PH intubation (coefficient −0.521, 95%CI −0.764, −0.277, p<0.01).

The median number of annual PH intubations was 0 (range 0, 34). Each additional 10 intubations at the EMS agency level was associated with an 23% decrease in odds of mortality in the risk-adjustment model (AOR 0.77, 95%CI 0.60—0.98, p=0.04). Linear regression demonstrated that each additional 10 intubations at the EMS agency level was associated with a 1min 20second decrease in scene time when adjusted for extrication (coefficient −1.326, 95%CI −1.864, −0.789, p<0.01).

In the context of prehospital triage criteria, prolonged scene time was associated with increased odds of mortality in patients with hypotension, GCS≤13, penetrating injury, flail chest, and pelvic fractures (Table 2). When adding extrication and PH intubation to the models, prolonged scene time remained significantly associated with increased mortality for patients with hypotension, penetrating injury, and flail chest (Table 2). Twenty-five percent of patients with hypotension, 48% with penetrating injury, and 18% with flail chest went immediately to the operating room from the ED.

The association between mortality and PH intubation was significantly attenuated in patients with GCS≤13 (AOR 2.72; 95%CI 2.41—3.10, p<0.01). When looking at patients with PH GCS≤8, this association was further diminished (AOR 1.82; 95%CI 1.54—2.14, p<0.01). Finally, a significant interaction was present between PH intubation and transport mode (p<0.01). PH intubation remained associated with mortality in patients transported by ground EMS with GCS≤8 (AOR 2.52; 95%CI 1.95—3.26, p<0.01) while prolonged scene time was not (p=0.29). In helicopter EMS patients with GCS≤8, however, mortality was not associated with PH intubation (AOR 1.26; 95%CI 0.92—1.73, p=0.15) or prolonged scene time (p=0.63), even when accounting for response and transport time.

DISCUSSION

The current study demonstrates that a prolonged scene time relative to other PH time intervals is associated with increased mortality in patients transported from the scene of injury. This association is present in both blunt and penetrating injury, although the odds of death are higher in penetrating injury as might be expected due to the frequent need for urgent operative intervention. Mortality increases with increasing scene time across quintiles of response and transport time. This relationship appears to be accentuated as travel time increases, suggesting as response and transport times increase, the detrimental impact of longer scene time increases.

Extrication and PH intubation partially mediated the association between mortality and prolonged scene time. Both interventions were associated with prolonged scene time and mortality. Further, adjusting for these factors resulted in significant attenuation for the association between prolonged scene time and mortality. Both interventions together mediated nearly two-thirds of the total effect between prolonged scene time and mortality. Exploratory analysis demonstrated increasing volume of extrications and PH intubations at the EMS agency level is associated with decreasing mortality and scene time, suggesting experience may impact outcome for these PH interventions. Further, prolonged scene time was not associated with mortality in patients not undergoing either extrication or PH intubation, suggesting these procedures facilitate the association between scene time and mortality rather than longer scene time alone.

When adjusting for mediators, prolonged scene time remained associated with increased mortality in patients with hypotension, penetrating injury, and flail chest, suggesting patients with these criteria have truly time-sensitive injuries. Finally, the association of PH intubation with increased mortality was significantly attenuated in patients with severe head injury and no longer present in patients with severe head injury intubated by helicopter EMS providers, adjusted for response and transport time which appear to compound the detrimental effects of prolonged scene time as they increase.

It is unclear from existing literature that minimizing PH time translates to improved outcomes. Early data did suggest shorter PH time was associated with improved outcomes. Sampalis and colleagues reported each additional minute of PH time was associated with a 5% increase in odds of death and TPT >60min was associated with a 3-fold increase in odds of death.[1, 16] Another early investigation reported significantly lower response time and TPT in unexpected survivors based on TRISS.[17]

However, most recent studies have not shown any association between PH time and mortality. Lerner et al found no association between mortality and TPT in trauma patients, while Pepe et al concluded the same in hypotensive patients with penetrating injury.[4, 6] Longer response time has not been linked to higher mortality in two large studies, as seen in the current data, while another reported increased mortality only when response time was >30min in rural areas.[8, 9, 18] Petri and colleagues were unable find a threshold for scene, transport, or TPT beyond which mortality increases. Recently, Newgard et al found no

association between response, scene, transport, or TPT and trauma mortality across 10 North American sites.[5]

Prior studies examine PH time using raw minutes. Raw PH times, however, suffer from high variability. This is evidenced by large standard deviations reported up to 28min, 22min, and 57min for response, scene, and transport times respectively in a meta-analysis of trauma PH time intervals.[10] Our approach of classifying patients by the distribution PH time intervals rather than using raw PH times may explain our findings. This approach also considers the time spent in each interval relative to others. Thus, patients with long raw scene times in other studies may have been classified as no prolonged PH time interval here if they also had longer response and transport intervals. Our results suggest patients fare worse when EMS spends more time on scene than it took to reach the patient and would take to transport them to the trauma center.

Our findings also suggest extrication and PH intubation mediate the association between mortality and prolonged scene time. PH intubation increases scene time between 1.8min to 10.7min in prior reports, which is on par with our findings.[19–22] Several groups report worse outcome in trauma patients undergoing PH intubation, similar to the current data.[23–29] Some postulate factors related to PH intubation may drive worse outcomes rather than simply extending scene time. Episodes of hypoxia, bradycardia, inadvertent hyperventilation, as well as procedural complications and errors may all contribute to worse outcomes.[25, 27, 29] Conversely, PH intubation has been shown to improve outcome in a minority of investigations.[2, 30, 31] Importantly, several investigations have shown PH intubation performed by helicopter EMS providers results in better outcomes, as was seen in the current study.[22, 27, 28, 31] Fakhry and colleagues suggested experience is a key component,[22] as helicopter EMS providers perform intubation more frequently than ground providers. Our data also suggest experience impacts outcome, with reduced scene time and mortality for increasing volume of intubations at the EMS agency level.

No studies examine extrication and patient outcomes. Extrication is not a procedure that can be deferred, and it would seem patients requiring extrication have increased mortality because of prolonged scene time. Despite this, there may be aspects of extrication that can be modified to improve outcome. This has giving rise to the concept of “medically directed rescue”.[32] This promotes a well-coordinated medical and rescue plan that allows for early patient assessment and interventions while extrication proceeds. A related concept of “damage control” extrication also aims to improve patient outcome.[33] As with truncated surgical procedures in the critically injured trauma patient, this approach to extrication encourages a rapid assessment of entrapped patients in order to recognize those who may benefit from expedited extrication. When these patients are identified, the emphasis on rapid extrication supersedes more conventional extrication techniques and the focus shifts to immediate removal of the entrapped patient in order to facilitate life-saving interventions and minimize scene time.

While no evidence currently demonstrates medically directed rescue or damage control extrication techniques improve outcome, our data shows increasing volume of extrications at the EMS agency level is associated with shorter scene time and reduced mortality. This

suggests that extrication can impact outcome, and that experience may be an important metric to consider. Directed study of these extrication approaches should be pursued to determine their potential to improve outcome.

It is important to consider the potential implications of these findings to prehospital trauma care. Some may interpret the current study as support for the “scoop and run” approach to prehospital trauma care. Several groups have shown that PH interventions are associated with longer PH time and worse outcome, particularly in penetrating trauma patients.[34–38]

We believe a more nuanced and cautious interpretation is warranted. In general, a “one size fits all” approach to prehospital trauma care is likely to result in suboptimal care, and some have shown improved outcomes for PH interventions in selected populations.[2, 39] This is why we performed subgroup analyses to identify patients based on triage criteria that have worse outcome associated with prolonged scene time. Hypotension, penetrating injury, and flail chest represent patients with genuinely time-sensitive injuries that frequently require urgent operation, and thus are a subset of patients that can be rapidly identified in the field to minimize scene time.

Further, the deleterious effect of PH intubation was increasingly attenuated with worsening head injury, and was not associated with mortality in severe head injury patients intubated by helicopter EMS providers. Thus, our data suggest there are select conditions under which PH interventions may be warranted.

These findings highlight the importance of PH time intervals relative to each other, rather than a set threshold of PH time. Awareness by EMS providers of scene time relative to the response and transport times is important. Distribution of prehospital time may be useful to examine in the quality improvement process by EMS medical directors, as using this type of metric can help individual agencies target areas for improvement without prescribing a specific time threshold that may not be practical for some patient scenarios or EMS systems. These findings may have implications for clinical care and EMS education if confirmed in additional study, and potential targets for action are highlighted in Table 3.

This study has several limitations for consideration. First is its retrospective design based on a state-wide trauma registry that was not intended to collect data specific to this study. Missing data was present; however, we used multiple imputation to mitigate this, which is a well validated technique for addressing missing data in trauma registry studies.[40–42] We did not impute PH times which were missing 12% of observations, as PH time intervals were integral to this study. We excluded patients with TPT<20min, as it seemed inappropriate to classify patients as having prolonged PH time intervals with very short TPT, although this cutoff was selected arbitrarily. For example, if a patient had a TPT of 10min, a scene time of 5min would qualify as a prolonged scene time; however, with such a short time there is unlikely anything that could be done to reduce a scene time significantly from 5min, and would not be a useful target to improve upon. These results may only be applicable in areas with similar trauma and EMS systems as those studied in Pennsylvania. Further, as this was an aggregate of state data, individual systems may fare differently, particularly in the setting of very short or long PH times.

The analyses beyond the primary objective should be considered exploratory. As we did not know beforehand which PH time interval(s) would be associated with mortality, the subsequent analyses were not pre-specified and should be interpreted as hypothesis-generating for future research. The volume based analyses for extrication and PH intubation were performed at the EMS agency level which may not be ideal. Extrication in most of the US is performed by fire services, and thus volume at the EMS agency level may not reflect volume at the fire agency level. Further, volume of intubations may be more important at the individual provider level rather than the EMS agency level. The available PH interventions for assessment as mediators were limited. We did not consider PH crystalloid volume as a mediator, as it was unclear whether this was instituted at the scene or during transport. Finally, there is potential selection bias. For instance, PH intubation may not be casually linked with mortality, but such a strong marker of severe injury or associated with unobserved confounding despite multivariable analysis.

CONCLUSION

Prolonged scene time relative to other PH time intervals is associated with increased mortality in trauma patients transported from the scene of injury. Prehospital factors including extrication and PH intubation that prolong scene time mediate this association. Further study should evaluate whether these factors drive increased mortality because they prolong scene time or whether they intrinsically worsen outcome by another mechanism, as reducing scene time is an actionable target to improve outcomes. Existing triage criteria can help identify patients in the field that benefit from reducing scene time.

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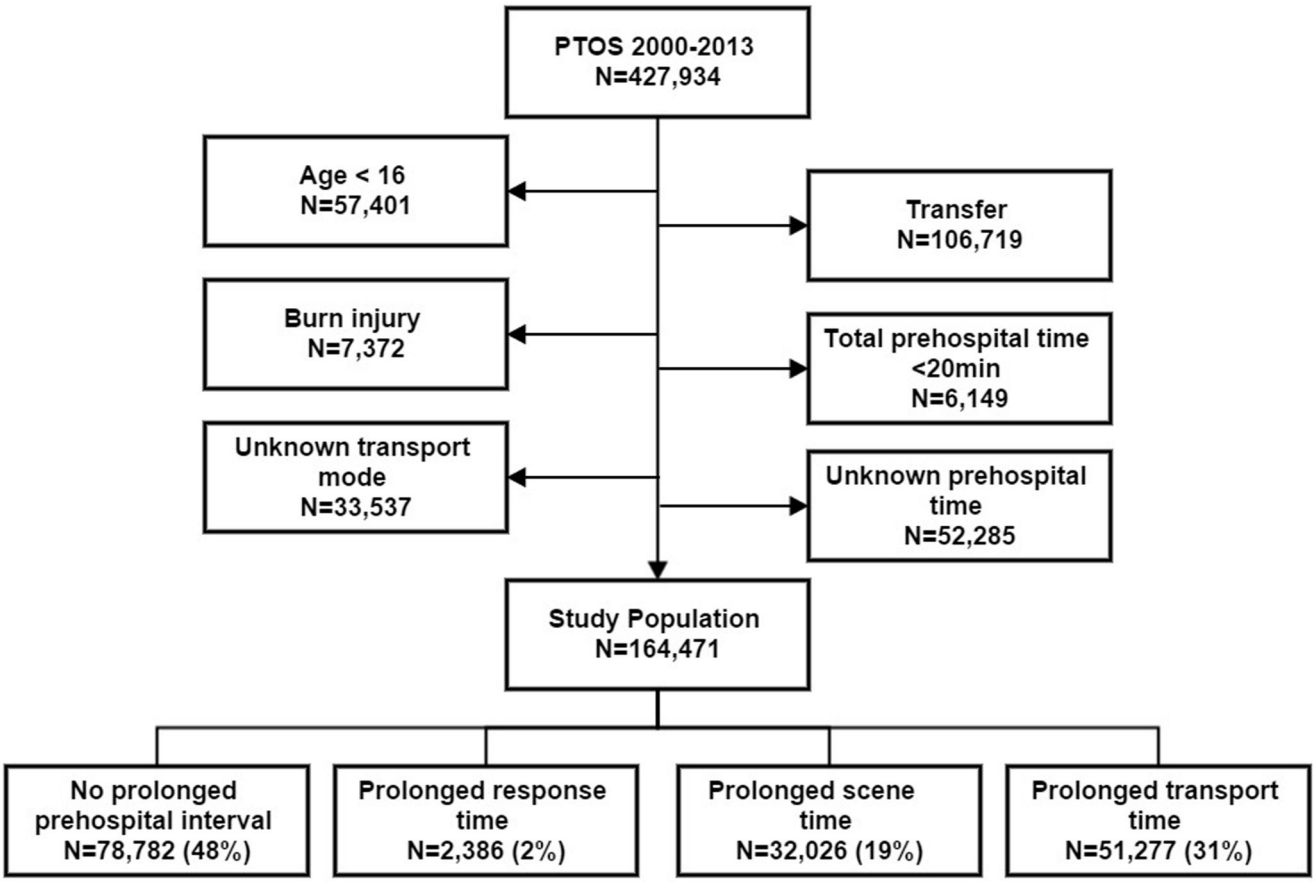

Figure 1.

Study participant selection from the Pennsylvania trauma registry January 2000 to June 2013 after application of eligibility criteria.

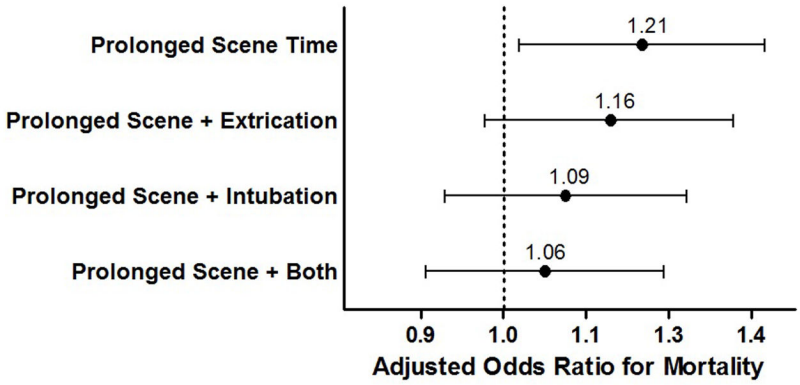

Figure 2.

Adjusted odds ratio of in-hospital mortality for prolonged scene time compared to no prolonged scene time under several risk-adjustment modeling scenarios for mediation testing. The top row represents the effect of prolonged scene time in the study population using the original risk-adjustment model without controlling for extrication or prehospital intubation. The second and third rows represent the association between prolonged scene time and mortality when controlling for extrication or prehospital intubation respectively in the study population. The bottom row represents association between prolonged scene time and mortality when controlling for both extrication and prehospital intubation in study population.

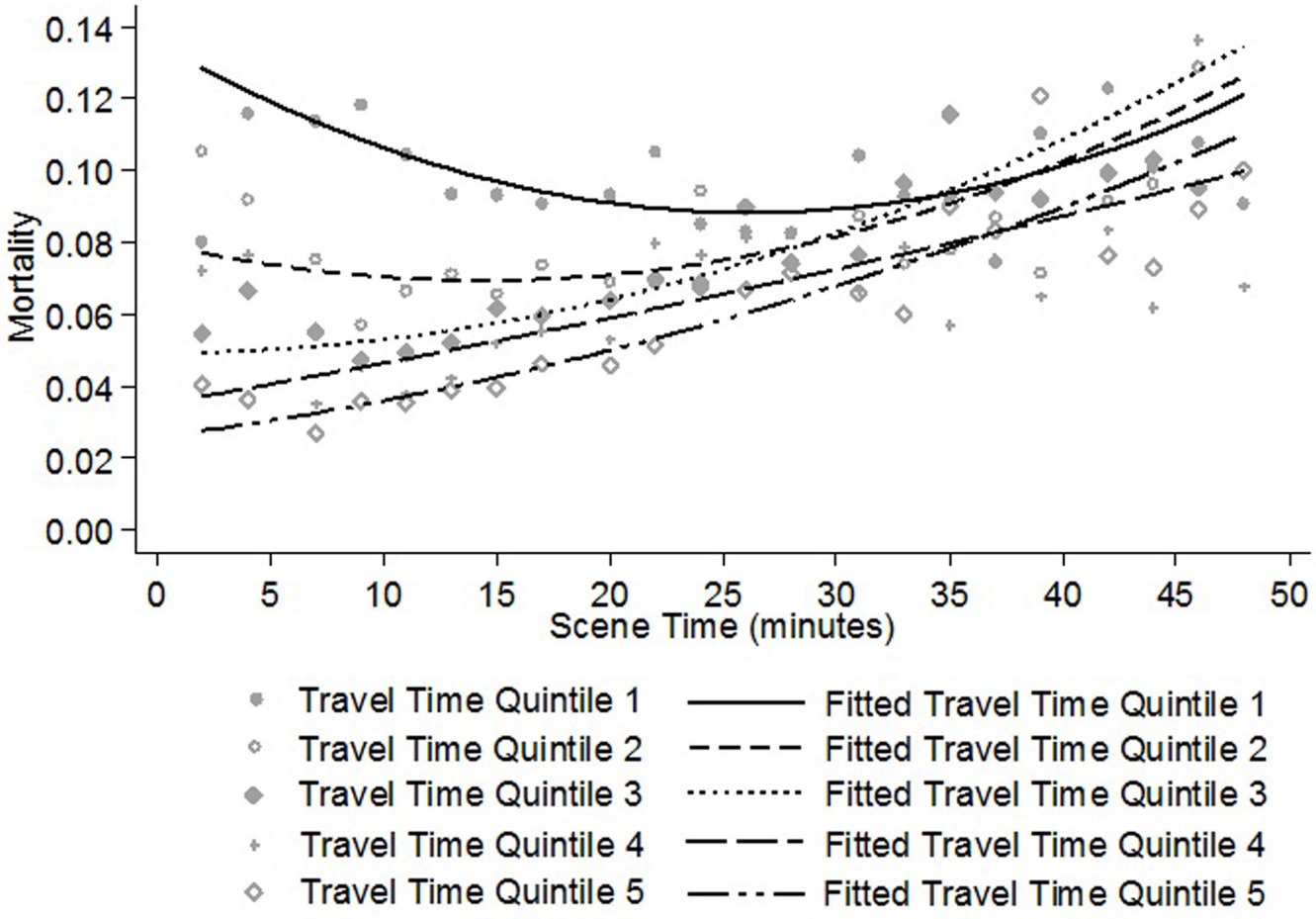

Figure 3.

Mortality and continuous scene time in minutes for each travel time (response time added to transport time) quintile. Regression lines represent quadratic regression fit with r^2 values ranging from 0.32 to 0.84. Regression lines demonstrate increasing direct correlation between mortality and scene time, indicating longer scene times have worse mortality at longer travel times.

Table 1

Unadjusted study population characteristics by prehospital time interval group

	No prolonged prehospital interval N=78,782	Prolonged response time N=2,386	Prolonged scene time N=32,026	Prolonged transport time N=51,277	p value
Response time (min)	11 (7, 15)	24 (20, 28)	4 (4, 9)	7 (4, 11)	<0.01
Scene time (min)	15 (11, 20)	9 (4, 11)	22 (17, 28)	11 (9, 15)	<0.01
Transport time (min)	15 (13, 22)	11 (7, 15)	11 (7, 15)	26 (22, 35)	<0.01
Total prehospital time (min)	42 (33, 54)	43 (33, 50)	39 (30, 50)	48 (37, 59)	<0.01
Response time (% of total time)	25.9 (19.6, 33.3)	52.9 (50.0, 57.1)	13.6 (8.3, 19.0)	15.3 (9.5, 21.2)	<0.01
Scene time (% of total time)	36.6 (29.7, 42.9)	19.6 (13.7, 25.4)	56.4 (52.4, 62.0)	25.9 (19.0, 32.3)	<0.01
Transport time (% of total time)	39.2 (33.3, 44.1)	27.0 (19.4, 32.3)	28.3 (21.2, 34.6)	56.9 (52.6, 62.9)	<0.01
Age (years)	47 (29, 69)	40 (25, 57)	48 (30, 70)	53 (34, 75)	<0.01
Sex (% male)	62.8	67.1	61.4	58.2	<0.01
Mechanism (% blunt)	92.9	90.7	92.3	94.5	<0.01
ISS	10 (5, 19)	13 (8, 21)	10 (5, 19)	9 (5, 16)	<0.01
Head AIS≥3 (%)	24.5	24.7	24.9	20.1	<0.01
Transport mode (%)					<0.01
Ground	64.4	40.5	84.5	90.6	
Helicopter	35.6	59.5	15.5	9.4	
Extrication required (%)	16.5	19.9	21.5	8.9	<0.01
Prehospital level of care (%)					<0.01
BLS	7.6	6.1	5.8	13.8	
ALS	92.4	93.9	94.2	86.2	
Prehospital intubation (%)	6.9	6.0	8.1	1.1	<0.01
ICU admission (%)	45.5	47.1	47.4	36.7	<0.01
Surgery for hemorrhage (%)	5.4	6.7	5.3	3.6	<0.01
In-hospital complication (%)	14.4	14.9	15.3	10.7	<0.01
Mortality (%)	7.3	8.0	9.4	4.5	<0.01

Continuous variables expressed as median (interquartile range)

ISS, injury severity score; AIS, abbreviated injury scale; BLS, basic life support; ALS, advanced life support; ICU, intensive care unit

Table 2

Regression results for association between prolonged scene time and mortality in prehospital criteria subgroups with a significant association

Criterion	AOR*	95%CI*	q value†
Risk-adjustment model without extrication or prehospital intubation			
Hypotension (SBP<90mmHg)	1.40	1.17 – 1.67	<0.01
Prehospital GCS≤13	1.14	1.02 – 1.29	0.04
Penetrating injury	1.59	1.29 – 1.97	<0.01
Flail chest	1.34	1.15 – 1.56	<0.01
Pelvic fracture	1.23	1.03 – 1.54	0.04
Risk-adjustment model adjusting for extrication and prehospital intubation			
Hypotension (SBP<90mmHg)	1.25	1.04 – 1.50	0.04
Penetrating injury	1.38	1.13 – 1.69	0.01
Flail chest	1.21	1.04 – 1.40	0.03

*Adjusted odds ratio and 95%CI for association of mortality with prolonged scene time

†False discovery rate adjusted p values; can be interpreted similarly to standard p values with significance defined as q≤0.05

AOR, adjusted odds ratio; 95%CI, 95% confidence interval; SBP, systolic blood pressure; GCS, Glasgow Coma Scale

Table 3

Summary of key findings and potential targets for action in prehospital trauma care

Key Finding	Potential actionable target	
Prolonged scene time relative to other prehospital time intervals is associated with increased mortality	**1**	Prehospital time distribution may be useful QI metric
	2	Emphasize situational awareness of scene time in relation to estimated transport time rather than a fixed scene time threshold
Mortality increases as scene time increases, and this relationship is intensified as response and transport time increase	**1**	Tailor emphasis of scene time based on typical and estimated response and transport times within EMS agencies or systems.
	2	Consider air medical transport in patients with unavoidable prolonged scene time to reduce transport time
Extrication and prehospital intubation mediate the effect of prolonged scene time on mortality, such that when these factors are controlled for the association is no longer significant	**1**	Less emphasis on scene time overall; focus placed on activities performed on scene
	2	Enhance training/involvement for EMS providers in extrication and prehospital intubation
Increasing number of extrications at the EMS agency level is associated with decreased scene time and mortality	**1**	Formal evaluation of outcomes using medically directed rescue and damage control extrication techniques; evaluate contribution of experience/volume to success of these techniques
	2	Develop quality metrics and educational initiatives for extrication techniques
Increasing number of prehospital intubations at the EMS agency level is associated with decreased scene time and mortality	**1**	Robust evaluation of contribution of experience and errors to adverse outcome for intubation
	2	Explore impact of alternate airway control methods that may be less time-consuming and/or require less skill (i.e. supraglottic airways)
	3	Establish provider/agency minimums for safe and effective intubation based on outcomes
For patients with hypotension, penetrating injury, and flail chest, prolonged scene time remains associated with increased mortality, even when controlling for extrication and prehospital intubation	**1**	Minimize scene time in these patients through expedited transport and performance of life-saving procedures en route; defer any procedures not immediately life-saving
The association of prehospital intubation and increased mortality diminishes as GCS decreases	**1**	Education to emphasize rapid identification of patients using objective findings that may require airway control in the field
	2	QI evaluation of prehospital intubation events with attention to indications, potential alternative care options, and outcomes
Prehospital intubation is not associated with increased mortality for patients with GCS≤8 intubated by helicopter EMS personnel	**1**	Identify and promulgate best-practices for protocols, training, and experience requirements to achieve high quality outcomes for intubation seen in HEMS programs
	2	Ground EMS agency assessment of capacity and volume to provide adequate training and experience for high quality intubation program

QI, quality improvement; EMS, emergency medical services; GCS, Glasgow Coma Scale; HEMS, helicopter emergency medical services