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Original Contribution

Accuracy of pre-hospital trauma notification calls

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ABSTRACT

Study objective: The aim of this study is to determine the accuracy of pre-hospital trauma notifications and the effects of inaccurate information on trauma triage.
Methods: This study was conducted at a level-1 trauma center over a two-year period. Data was collected from pre-notification forms on trauma activations that arrived to the emergency department via ambulance. Trauma activations with pre-notification were compared to those without notification and pre-notification forms were assessed for accuracy and completeness.
Results: A total of 2186 trauma activations were included in the study, 1572 (71.9%) had pre-notifications, 614 (28.1%) did not and were initially under-triaged. Pre-notification forms were completed for 1505 (95.7%) patients, of which EMS provided incomplete/inaccurate information for 1204 (80%) patients and complete/accurate information for 301 (20%) patients. Missing GCS/AVPU score (1099, 91.3%), wrong age (357, 29.6%), and missing vitals (303, 25.2%) were the main problems. Missing/wrong information resulted in trauma tier over-activation in 25 (2.1%) patients and under-activation in 20 (1.7%) patients. Under-triaged patients were predominantly male (18, 90%), sustained a fall (9, 45%), transported by BLS EMS teams (12, 60%), and arrived on a weekday (13, 65%) during the time period of 11 pm–7 am (9, 45%). A total of 13 (65%) required emergent intubation, 2 (10%) required massive transfusion activation, 7 (35%) were admitted to ICU, 3 (15%) were admitted directly to the OR, and 1 (15%) died.
Conclusion: EMS crews frequently provide inaccurate pre-hospital information or do not provide any pre-hospital notification at all, which results in over/under triage of trauma patients.

1. Introduction

Emergency medical services (EMS) often utilize a pre-notification system to alert the receiving hospital of its arrival with an injured or critically ill patient. EMS' pre-notification guidelines are based on physical findings, mechanism of injury, and the risk of mortality [1]. Pre-notification allows proper in-hospital resource utilization. For trauma patients, the information communicated includes estimated time of arrival, mechanism of injury, site of injury, age, gender, vital signs, and Glasgow Coma Scale (GCS) [1, 2]. Based on the information provided the receiving hospital decides if a trauma activation is warranted and the level of trauma activation that is needed. Trauma activation initiates the assembly of a trauma team and the preparation of resources prior to the arrival of the patient. This prevents delays in the treatment of critically injured patients and can improve outcome and reduce mortality [3-5].

The transfer of pre-hospital information can occur via direct communication between EMS and hospital staff or via a dispatcher who relays the information provided by EMS to the hospital. This verbal communication between the EMS/dispatcher and hospital staff is prone to errors. Inadequate or inaccurate pre-notification can lead to under-triage or over-triage of patients. Under-triage is of particular concern, since it can have a direct impact on patient outcome and safety and in some cases lead to mortality [6]. Conversely, unnecessary assembly of trauma resources impacts operations throughout the hospital. Medical personnel and services placed on hold for the arriving patient delays the treatment of other non-trauma patients. Therefore, pre-notification and trauma activation should be done accurately and only when necessary.

In-hospital handoff between EMS and hospital staff has been studied [7-9]. However, fewer studies have assessed the en-route communication between EMS and hospital staff [10-17]. One of the earlier studies

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by Brown and colleagues demonstrated that information was missing from the pre-alert calls that would have been useful for better preparation and mobilization of resources [11]. They also demonstrated that there were clinically critical patients that did not have prior-alert calls. The majority of these patients required admission to intensive care [11]. Similar results were reported in two other studies, no prior alert was made for 56–60% of the critically ill patients transported by ambulance crews [12, 14]. A retrospective analysis of pre-notification of arriving trauma patients revealed that EMS underestimated time of arrival, which resulted in premature trauma team assembly [17]. These studies demonstrate that EMS either inadequately or inaccurately alerts hospitals on critically ill or injured patients.

The EMS pre-notification system has an impact on the under- and over- triage rates of trauma patients. According to the American College of Surgeons Committee on Trauma (ACSCOT), the over-triage rate of trauma patients should be <50% and the under-triage rate should be <5% [2]. In order for trauma centers to adhere to these standards, EMS pre-notification has to be an accurate and efficient process. Several factors may play a role in inaccurate or missing pre-hospital information. This may include the EMS transportation company, the experience of the EMS personnel, and technical challenges. In New York, at the state and regional level, improving the EMS pre-notification system is a top priority for trauma centers. The aim of this study is to determine what factors affect the accuracy of pre-hospital information and the effects of inaccurate information on trauma triage.

2. Methods

This prospective study included trauma activation patients, over a two year period, who presented to the Emergency Department (ED) at an urban, adult, level 1 trauma center. Our internal EMS/dispatcher pre-notification forms were reviewed to obtain information provided by EMS/dispatcher to hospital staff. Variables which may affect the accuracy of the pre-hospital information such as, mode of transport, EMS Transport Company, and mechanism of injury were also collected. This study was approved by the Institutional Review Board; patient consent was not required.

2.1. Setting

This study was performed at a Level 1 trauma center where there are three tiers of trauma activations, with the urgency and severity increasing from tier 3 to tier 1. Tier 3 traumas have the lowest urgency and injury severity; they require a trauma consult within 30 min of an injury being identified by an emergency medicine physician. Tier 3 activations were excluded from the study. Trauma activations are managed by a team consisting of an emergency medicine physician, attending trauma surgeon, surgical resident team, anesthesia attending, trauma program manager, respiratory therapist, radiology technician, social services, two ED registered nurses, and security services. The trauma surgeon and the anesthesia attending are only required to be present at tier 1 activations. For tier 2 activations, the chief surgical resident is required to be present, while the presence of the trauma surgeon is optional unless deemed necessary. ED physicians are present at all trauma activations. Upon trauma activation, all trauma team members have a maximum of 15 min to arrive in the trauma bay.

2.1.1. Tier 2 activation criteria

1) Falls from a height of >20 ft for adults, >10 ft for children, 3× the height of the patient, or from any height if the patient is on anticoagulation medications.
2) High risk auto crash with intrusion of vehicle >12 in. on occupant side or >18 in. on other side of vehicle, ejection (partial or complete) from automobile, death of one of the occupants, auto vs. pedestrian/cyclist, motorcycle crash >20 mph.
3) High-energy dissipation or rapid decelerating incidents, for example: ejection from motorcycle, ATV, animal, etc., striking a fixed object with momentum, a blast or an explosion.
4) High-energy electrical injury, burns >10% of total body surface area (2nd or 3rd degree) and/or inhalation injury.
5) Suspicion of hypothermia, drowning, hanging, or non-accidental trauma.
6) Blunt abdominal injury with distended abdomen or with seatbelt imprint.

2.1.2. Tier 1 activation criteria

In addition to Tier 2 criteria, the following criteria are needed for Tier 1 trauma activations:

1) Breathing: respiratory rate: >29 or <10 breaths per minute, respiratory insufficiency, hypoxia, accessory muscle use, grunting.
2) Circulation: systolic blood pressure <90 mm Hg, capillary refill >2 s.
3) Mental status: GCS ≤13 (≤"P" on AVPU), motor score ≤5.
4) Airway: field intubation (or attempted), unable to adequately intubate.
5) Injuries: an open/depressed skull fracture, paralysis or suspected spinal cord injury, a flail chest, an unstable pelvic fracture, amputation proximal to wrist or ankle, two or more proximal long bone fractures, a crushed, degloved, or mangled extremity, a penetrating injury to the head, neck, torso, or extremities proximal to the elbow/knee, transfers requiring blood transfusion, or deterioration of a previously stable patient.

2.2. Study design

2.2.1. Trauma activation protocol and EMS data collected

EMS both directly and indirectly (via a dispatcher) communicated with ED nursing staff via phone and relayed information on the incoming patient. The information was recorded on an internal pre-notification form developed by members of the ED/Trauma department. The form was designed to record: date, time, estimated time of arrival, age, gender, mode of transport (advanced life support (ALS) vs. basic life support (BLS)), vitals, Glasgow Coma Scale (GCS), Alert-Voice-Pain-Unresponsive (AVPU) scale, mechanism of injury and site of injury. Trauma activation was then initiated based on the institution's criteria for trauma activation and level of activation.

Pre-hospital data was assessed for accuracy and completeness. Information provided by EMS via the pre-notification calls was compared to in-hospital data collected upon patient arrival. If any of the variables collected on the pre-notification form differed from the in-hospital information it was considered inaccurate. The data collected from EMS during the pre-notification call was considered incomplete if any of the variables on the form was not provided. To ensure validity, the ambulance call report was also reviewed to determine if the data matched the pre-notification information. Trauma tier under-activation based on inaccurate/incomplete information provided by EMS or trauma activation without prior notification from EMS was considered under-triage. Progression of injury was taken into consideration. If during in-hospital EMS hand-off if it was noted that the patient decompensated en-route to the hospital, this was not considered under-triage. Unnecessary or over trauma tier activation due to inaccurate/incomplete information from EMS was considered over-triage. Trauma activations with and without pre-hospital notification were also compared. Trauma activations without pre-hospital notification included 13 patients that according to EMS had pre-notification via a dispatcher, but the call was not received by hospital staff. In New York, EMS have criteria by which they determine if a prior alert is needed. These criteria were reviewed for each trauma activation to ensure the decision by EMS to pre-notify or not pre-notify the hospital was justified based on their own criteria.

2.2.2. Emergency medical services

MediSys is our institution's private EMS company; all other EMS companies were grouped as “Other”. In some cases, the EMS company was not recorded in the medical chart and was therefore grouped as “Unknown”.

2.2.3. Variables collected in-hospital

Age, gender, date and time of arrival, mechanism of injury, trauma tier level, arrival mode, mode of transport, transportation company, disposition time, length of stay in the ED, ED disposition, ED vital signs, time to the operating room, intubation status, massive transfusion protocol (MTP) activation, alcohol use, drug use, injury severity score, mortality rate. For mechanism of injury, a fall was defined as inadvertently coming to rest on the ground or other lower level.

2.2.4. Inclusion and exclusion criteria

All patients that presented to the Emergency Department as tier 1 or tier 2 trauma activations during the period of February 1st, 2014 and January 31st, 2016 were included. Exclusions included ‘walk-in’ patients who did not arrive by ambulance and patients who were transferred in from another hospital.

2.3. Data analysis

Tier 1 and tier 2 trauma activations with and without pre-hospital notifications were compared as well as trauma activations with complete/accurate and incomplete/inaccurate pre-hospital information. The pre-hospital notification forms were analyzed to determine under and over trauma activation. To analyze data GraphPad Prism 6 (GraphPad Software Inc., La Jolla, CA) was used, $p < 0.05$ was considered significant. Categorical variables are expressed as count (N) and percent (%) and continuous variables are expressed as median and interquartile range (IQR). For categorical variables, significance testing was done using Fisher's exact test; the difference between proportions and odds ratios were calculated along with a 95% confidence interval (CI). For continuous variables, the sample was first assessed for normality using the Shapiro-Wilk normality test followed by the Mann-Whitney non-parametric test. The difference between medians was also calculated with a corresponding 95% confidence interval.

3. Results

During the study period, a total of 2186 trauma activations were initiated for patients who arrived at the emergency room via EMS. The hospital received prior notification for 1572 (71.9%) of these trauma activations, while 614 (28.1%) had no prior notification and were activated upon patient arrival based on the ED physician's discretion. The median age was 41 (IQR: 27, 58) years, 1588 (72.6%) were male, and the median injury severity score (ISS) was 4 (IQR: 1, 10). Blunt trauma was the main mechanism of injury (1804, 82.5%). There were more tier 2 activations (67.4%) than tier 1 activations (32.6%) and most patients arrived with basic life support (BLS) EMS teams (66.7%).

Trauma activations with and without pre-notification were compared in Tables 1 and 2. For both tier 1 and tier 2 trauma activations, there were some significant differences between activations with and without pre-notification. There were 15.8% more pre-notification calls for tier 1 trauma activations that were transported by ALS EMS teams ($p = 0.006$) and 9.1% more calls for patients who had gunshot wounds ($p = 0.039$). On the other hand, tier 1 trauma patients without pre-notification had a median increase of 81.5 min spent in the ED ($p = 0.002$). Similar to tier 1 activations, there were 6.2% more pre-notifications for tier 2 activations that were transported by ALS teams ($p = 0.004$), 5.4% more pre-notifications for assault patients ($p = 0.0006$) and 2.5% more pre-notifications for gunshot wound patients ($p = 0.006$). Additionally, tier 2 activations that arrived without pre-notification had a median increase of 32 min spent in the ED (p =

Table 1
Comparison of trauma activations with and without pre-notification.

Variable	Tier 1 trauma activations				Tier 2 trauma activations			
	Pre-notification (n = 624) N (%) or median (IQR)	No pre-notification (n = 89) N (%) or median (IQR)	Difference (95% CI)	p value	Pre-notification (n = 948) N (%) or median (IQR)	No pre-notification (n = 525) N (%) or median (IQR)	Difference (95% CI)	p value
Age (years)	34.5 (IQR: 25, 53)	33 (IQR: 22, 49.5)	1.5 (−5.0–2.0)	0.410	43 (IQR: 27, 58)	48 (IQR: 31, 69)	−5 (3–8)	<**0.0001***
Gender								
Male	509 (81.6%)	79 (88.8%)	−7.2 (−1.2–15.6)	0.102	667 (70.4%)	331 (63%)	7.3 (2.3–12.3)	**0.004***
Female	115 (18.4%)	10 (11.2%)	7.2 (−1.2–15.6)	0.102	281 (29.6%)	194 (37%)	−7.3 (2.3–12.3)	**0.004***
Mode of transport								
ALS	274 (43.9%)	25 (28.1%)	15.8 (4.9–26.8)	**0.006***	205 (21.6%)	81 (15.4%)	6.2 (2.0–10.4)	**0.004***
BLS	327 (52.4%)	54 (60.7%)	−8.3 (−2.8–19.3)	0.173	669 (70.6%)	408 (77.7%)	−7.1 (2.4–11.9)	**0.003***
Unknown	23 (3.7%)	10 (11.2%)	−7.5 (2.9–12.2)	**0.004***	74 (7.8%)	36 (6.9%)	0.9 (−1.8–3.7)	0.536
EMS company								
MediSys	186 (29.8%)	14 (15.7%)	14.1 (4.1–24.1)	**0.005***	292 (30.8%)	137 (26.1%)	4.7 (−0.1–9.5)	0.063
Other	434 (69.5%)	75 (84.3%)	−14.7 (4.7–24.8)	**0.004***	646 (68.1%)	385 (73.3%)	−5.2 (0.3–10.1)	**0.038***
Unknown	4 (0.6%)	0 (0%)	0.6 (−3.5–1.6)	1.000	10 (1%)	3 (0.6%)	0.4 (−0.7–1.4)	0.401
Day of injury								
Weekday	251 (40.2%)	50 (56.2%)	−16 (5–26.9)	**0.006***	603 (63.6%)	344 (65.5%)	−1.9 (−3.2–7.0)	0.496
Weekend	373 (59.8%)	39 (43.8%)	16 (5–26.9)	**0.006***	345 (36.4%)	181 (34.5%)	1.9 (−3.2–7.0)	0.496
Time of injury								
7 AM–3 PM	146 (23.4%)	15 (16.8%)	6.5 (−2.7–15.8)	0.178	225 (23.7%)	146 (27.8%)	−4.1 (−0.5–8.7)	0.091
3 PM–11 PM	260 (41.7%)	34 (38.2%)	3.5 (−7.5–14.4)	0.566	406 (42.8%)	217 (41.3%)	1.5 (−3.8–6.7)	0.582
11 PM–7 AM	218 (34.9%)	40 (44.9%)	−10 (−0.7–20.7)	0.077	317 (33.4%)	162 (30.9%)	2.6 (−2.4–7.6)	0.324
Season of injury								
Winter	108 (17.3%)	24 (27%)	−9.7 (1.0–18.3)	**0.040***	200 (21.1%)	116 (22.1%)	−1.0 (−3.4–5.4)	0.691
Spring	181 (29%)	26 (29.2%)	−0.2 (−9.9–10.3)	1.000	237 (25%)	104 (19.8%)	5.2 (0.7–9.7)	**0.024***
Summer	179 (28.7%)	19 (21.3%)	7.3 (−2.6–17.3)	0.165	295 (31.1%)	168 (32%)	−0.9 (−4.1–5.8)	0.726
Autumn	156 (25%)	20 (22.5%)	2.5 (−7–12.1)	0.694	216 (22.8%)	137 (26.1%)	−3.3 (−1.2–7.9)	0.161

Categorical variables are expressed as count (N) and percentage and continuous variables are expressed as median and interquartile range (IQR); CI, confidence interval; ALS, advanced life support; BLS, basic life support; EMS, emergency medical services; * and bold values = $p < 0.05$.

Table 2
Comparison of trauma activations with and without pre-notification.

Variable	Tier 1 trauma activations				Tier 2 trauma activations			
	Pre-notification (n = 624) N (%) or median (IQR)	No pre-notification (n = 89) N (%) or median (IQR)	Difference (95% CI)	p value	Pre-notification (n = 948) N (%) or median (IQR)	No pre-notification (n = 525) N (%) or median (IQR)	Difference (95% CI)	p value
Blunt trauma	364 (58.3%)	55 (61.8%)	−3.5 (−7.5–14.4)	0.566	886 (93.5%)	499 (95%)	−1.6 (−0.9–4.1)	0.251
Fall	131 (21%)	23 (25.8%)	−4.8 (−4.3–14)	0.335	315 (33.2%)	232 (44.2%)	−11 (5.8–16.1)	**<0.0001***
MVA	103 (16.5%)	10 (11.2%)	5.3 (−2.8–13.4)	0.276	254 (26.8%)	121 (23%)	3.7 (−0.9–8.4)	0.119
Assault	35 (5.6%)	10 (11.2%)	−5.6 (0.2–11.0)	0.058	109 (11.5%)	32 (6.1%)	5.4 (2.2–8.5)	**0.0006***
Pedestrian struck	79 (12.7%)	7 (7.9%)	4.8 (−2.4–12)	0.226	182 (19.2%)	97 (18.5%)	0.7 (−3.4–4.9)	0.781
Other	16 (2.6%)	5 (5.6%)	−3 (−0.5–10)	0.167	26 (2.7%)	17 (3.2%)	−0.5 (−1.3–2.3)	0.629
Penetrating trauma	257 (41.2%)	34 (38.2%)	3.0 (−7.9–13.9)	0.645	62 (6.5%)	26 (4.9%)	1.6 (−0.9–4.1)	0.251
Assault – GSW	120 (19.2%)	9 (10.1%)	9.1 (0.6–17.7)	**0.039***	36 (3.8%)	7 (1.3%)	2.5 (0.7–4.3)	**0.006***
Assault – SW	129 (20.7%)	25 (28.1%)	−7.4 (−1.7–16.6)	0.129	21 (2.2%)	15 (2.9%)	−0.6 (−1.0–2.3)	0.482
Other	8 (1.3%)	0 (0%)	1.3 (−2.9–2.5)	0.605	5 (0.5%)	4 (0.8%)	−0.2 (−0.6–1.4)	0.729
Unknown mechanism of injury	3 (0.5%)	0 (0%)	0.5 (−3.7–1.4)	1.000	0 (0%)	0 (0%)	0 (−0.7–0.4)	1.000
ED LOS (mins)	225.5 (IQR: 79, 419)	307 (IQR: 161.5, 549)	−81.5 (30–142)	**0.002***	364 (IQR: 249.5, 538)	396 (IQR: 282.5, 566)	−32 (2–48)	**0.032***
Time to first OR visit (mins)	206 (IQR: 52, 1468)	185 (IQR: 54.2, 1699)	21 (−140–97)	0.957	1434 (IQR: 559.5, 3597)	1773 (IQR: 530, 2974)	−339 (−313, 416)	0.847
Direct ED admit to OR (MINS)	68 (IQR: 35, 132)	133 (IQR: 54, 179.5)	65 (−37–107)	0.280	269.5 (IQR: 116, 452.5)	177 (IQR: 72, 242.8)	92.5 (−262–6)	0.065
Emergent intubation	203 (32.5%)	37 (41.6%)	−9 (−1.5–19.5)	0.095	62 (6.5%)	25 (4.8%)	1.8 (−0.7–4.3)	0.204
MTP activation	37 (5.9%)	2 (2.2%)	3.7 (−2.1–6.4)	0.212	2 (0.2%)	3 (0.6%)	−0.4 (−0.3–1.5)	0.355
Alcohol use	216 (34.6%)	47 (52.8%)	−18.2 (7.5–28.9)	**0.001***	289 (30.5%)	150 (28.6%)	1.9 (−3.0–6.8)	0.475
Drug use	112 (17.9%)	21 (23.6%)	−5.6 (−3–14.3)	0.194	149 (15.7%)	102 (19.4%)	−3.7 (−0.3–7.7)	0.071
Injury severity score (ISS)	9 (IQR: 2, 17)	5 (IQR: 1, 14)	4 (−3–0)	0.096	4 (IQR: 1, 9)	4 (IQR: 1, 9)	0 (0–0)	0.070
ISS ≥ 16	205 (32.8%)	21 (23.6%)	9.3 (−1.1–19.6)	0.088	107 (11.3%)	36 (6.9%)	4.4 (1.3–7.6)	**0.006***
ISS < 16	419 (67.1%)	68 (76.4%)	−9.3 (−1.1–19.6)	0.088	841 (88.7%)	489 (93.1%)	−4.4 (1.3–7.6)	**0.006***
ED disposition								
Home	133 (21.3%)	21 (23.6%)	−2.3 (−6.9–11.4)	0.679	371 (39.1%)	202 (38.5%)	0.6 (−4.5–5.8)	0.823
Floor	282 (45.2%)	45 (50.6%)	−5.4 (−5.7–16.4)	0.364	474 (50%)	278 (52.9%)	−2.9 (−2.4–8.3)	0.301
ICU	74 (11.9%)	12 (13.5%)	−1.6 (−5.6–8.9)	0.606	57 (6%)	21 (4%)	2.0 (−0.4–4.4)	0.114
OR	67 (10.7%)	5 (5.6%)	5.1 (−2.1–9.3)	0.186	24 (2.5%)	8 (1.5%)	1.0 (−0.5–2.6)	0.263
Psychiatry	4 (0.6%)	0 (0%)	0.6 (−3.5–1.6)	1.000	3 (0.3%)	5 (0.9%)	−0.6 (−0.2–1.9)	0.142
Left AMA	6 (1%)	1 (1.1%)	−0.2 (−1.3–5.2)	1.000	13 (1.4%)	3 (0.6%)	0.8 (−0.4–1.8)	0.195
Mortality	56 (9%)	4 (4.5%)	4.5 (−2.3–8.2)	0.218	1 (0.1%)	1 (0.2%)	−0.08 (−0.4–1.0)	1.000
Transferred	2 (0.3%)	1 (1.1%)	−0.8 (−0.4–5.8)	0.330	5 (0.5%)	7 (1.3%)	−0.8 (−0.2–2.2)	0.130

Categorical variables are expressed as count (N) and percentage and continuous variables are expressed as median and interquartile range (IQR); CI, confidence interval; MVA, motor vehicle accident; GSW, gunshot wound; SW, stab wound; ED, emergency department; LOS, length of stay; OR, operating room; MTP, massive transfusion protocol; ICU, intensive care unit; AMA, against medical advice; * and bold values = $p < 0.05$.

0.032), 7.1% more were transported by BLS teams ($p = 0.003$), 11% more were fall patients ($p < 0.0001$), and 4.4% more had an ISS <16 ($p = 0.006$). Additional information is provided in Tables 1 and 2.

A total of 1505 (95.7%) internal pre-notification forms were completed for the 1572 trauma activations that arrived with pre-hospital notification. EMS/dispatcher provided incomplete or wrong information for 1204 (80%) of these patients (Table 3). Missing GCS/AVPU score (1099, 91.3%), wrong age (357, 29.6%), and missing vitals (303, 25.2%) were the most common problems. Incomplete or wrong information resulted in trauma tier over-activation in 25 (2.1%) patients and trauma tier under-activation in 20 (1.7%) patients (Table 3). Patients under-triaged due to incomplete/wrong information were predominantly male (90%), transported by a BLS EMS team (60%), and arrived on a weekday (65%) during the time period of 11 pm–7 am (45%). In addition, the mechanism of injury for 9 (45%) patients was a fall, 13 (65%) required intubation, 2 (10%) required MTP activation, 7 (35%) were admitted to ICU, 3 (15%) were admitted directly to the OR from the ED, and 1 (5%) died in the trauma bay.

In Tables 4 and 5, trauma activations with complete/accurate pre-notification information were compared to those with incomplete/inaccurate information. There were 11.9% more tier 1 patients with incomplete/inaccurate pre-notification information that tested positive for alcohol use ($p = 0.045$) and 6.4% more died in the trauma bay ($p = 0.044$). For tier 2 pre-notifications with incomplete/inaccurate information, 10.2% more were male ($p = 0.005$), 13.9% more were during the 11 pm–7 am time period ($p = 0.0002$), and 12.5% more patients tested positive for alcohol use ($p = 0.0004$). Tier 2 trauma patients with incomplete/inaccurate information also had a median delay of 512.5 min to the first operating room visit ($p = 0.016$) and a 3.9% increase in emergent intubations ($p = 0.036$). Detailed information is provided in Tables 4 and 5.

The outcomes of tier 1 activations with complete/accurate information were compared to tier 1 activations that were initially under-activated due to incomplete/inaccurate information provided by EMS (Table 6). Under-activated tier 1 traumas required 42.3% more emergent intubations ($p = 0.002$) and had 32.7% more patients that required admission to the ICU ($p = 0.003$) compared to tier 1 activations with complete/accurate information. On the other hand, a total of 19 (23.2%) tier 1 trauma activations with complete/accurate information were discharged home from the ED, while no patients who were under-activated due to incomplete/inaccurate information were discharged home from the ED ($p = 0.037$) (Table 6).

4. Discussion

Pre-hospital trauma notification allows hospitals to prepare for the arriving patient and ensures that there are no delays in treating seriously injured patients. This verbal communication between emergency medical services/dispatchers and hospital staff can be prone to errors, which may result in inappropriate trauma triage and resource allocation. The aim of this study was to determine the accuracy of pre-hospital information and the effects of inaccurate information on trauma triage. We demonstrated that pre-hospital notification can be inaccurate or inadequate, which prevents appropriate trauma triage.

Table 3
Wrong or missing pre-notification information provided by EMS/dispatcher.

Variable (pre-notification form) (n = 1505)	N (%)
Number of patients with pre-notification forms	1505
Number of forms with complete/accurate information	301/1505 (20)
Number of forms with missing/wrong information	1204/1505 (80)
Age missing	42/1204 (3.5)
Wrong age	357/1204 (29.6)
Gender missing	40/1204 (3.3)
Wrong gender	15/1204 (1.2)
GCS/AVPU missing	1099/1204 (91.3)
Wrong GCS	3/1204 (0.2)
Vitals missing (all)	303/1204 (25.2)
Blood pressure missing	152/1204 (12.6)
Respiratory rate missing	279/1204 (23.2)
Pulse missing	161/1204 (13.4)
Mechanism of injury missing	126/1204 (10.5)
Wrong mechanism of injury	4/1204 (0.3)
EMS/dispatcher overactivation (trauma tier downgraded)	25/1204 (2.1)
Wrong age	1/25 (4)
GCS/AVPU missing	3/25 (12)
Vitals missing (all)	5/25 (20)
Wrong site of injury	9/25 (36)
Mechanism of injury missing	4/25 (16)
Wrong mechanism of injury	6/25 (24)
EMS/dispatcher underactivation (trauma tier upgraded)	20/1204 (1.7)
GCS/AVPU missing	6/20 (30)
Vitals missing (all)	3/20 (15)
Wrong site of injury	5/20 (25)
Mechanism of injury missing	1/20 (5)
Wrong mechanism of injury	6/20 (30)

GCS, Glasgow Coma Scale Score; AVPU, Alert-Voice-Pain-Unresponsive Scale Score; EMS, emergency medical services.

Furthermore, no pre-hospital notification was made for a substantial number of patients.

Approximately one third of the trauma activations did not have a pre-hospital notification and only a handful of these patients had a progression of injury during transport to the ED. Therefore, the ability of EMS to correctly identify patients who require prior notification is lacking. For patients without pre-notification, trauma activation was initiated after triage in the ED, 593 (27.1%) patients were initially undertriaged due to a lack of pre-notification. Tier 2 trauma activations were more likely to arrive with no pre-notification compared to tier 1 trauma activations. This implies that there is more ambiguity or reduced urgency with less severely injured patients. BLS EMS teams were more likely to transport patients without alerting the hospital. This may explain the uncertainty with less severely injured patients, a lack of training or experience may account for a decrease in pre-hospital notifications.

In regards to trauma activations with pre-notification, no information or wrong information was given for most of the patients in the study. GCS/AVPU score was the primary missing variable, while vital signs were secondary. Neurological status and vital signs are critical in determining the extent of injury and thus, the level of trauma activation and the resources that are needed. Missing GCS/AVPU and vital signs resulted in a change in the level of trauma activation for only a few patients. GCS can help determine if there is a head injury that requires a CT scan or airway management, while vital signs such as respiratory rate can help identify patients with respiratory compromise that may require an anesthesiologist on arrival to the trauma bay. The high percentage of patients without vital signs or GCS/AVPU recorded suggests a lack of assessment by EMS at the scene of the incident or failure to record them due to the severity of the patient.

Table 4
Comparison of trauma activations with complete/accurate vs. incomplete/inaccurate pre-notification information.

Variable	Tier 1 trauma activations				Tier 2 trauma activations			
	Complete/accurate pre-notification information (n = 82) N (%) or median (IQR)	Incomplete/inaccurate pre-notification information (n = 518) N (%) or median (IQR)	Difference (95% CI)	p value	Complete/accurate pre-notification information (n = 219) N (%) or median (IQR)	Incomplete/inaccurate pre-notification information (n = 686) N (%) or median (IQR)	Difference (95% CI)	p value
Age (years)	31 (IQR: 23, 47.2)	35 (IQR: 26, 53)	−4 (0–6)	0.066	39 (IQR: 26, 57)	44 (IQR: 27, 58)	−5 (−1–4)	0.262
Gender								
Male	66 (80.5%)	423 (81.7%)	−1.2 (−7.9–10.2)	0.762	138 (63%)	502 (73.2%)	−10.2 (3.2–17.1)	**0.005***
Female	16 (19.5%)	95 (18.3%)	1.2 (−7.9–10.2)	0.762	81 (37%)	184 (26.8%)	10.2 (3.2–17.1)	**0.005***
Mode of transport								
ALS	33 (40.2%)	232 (44.8%)	−4.5 (−7.0–16.1)	0.474	45 (20.5%)	149 (21.7%)	−1.2 (−5.1–7.4)	0.777
BLS	46 (56.1%)	266 (51.3%)	4.7 (−6.9–16.4)	0.476	156 (71.2%)	486 (70.8%)	0.4 (−6.5–7.3)	0.932
Unknown	3 (3.7%)	20 (3.9%)	−0.2 (−6.5–3.3)	1.000	18 (8.2%)	51 (7.4%)	0.8 (−3.2–4.8)	0.664
EMS company								
MediSys	33 (40.2%)	150 (29%)	11.3 (0.6–22)	0.052	79 (36.1%)	198 (28.9%)	7.2 (0.2–14.2)	0.053
Other	49 (59.8%)	364 (70.3%)	−10.5 (−0.3–21.3)	0.072	137 (62.6%)	481 (70.1%)	−7.6 (0.5–14.6)	**0.037***
Unknown	0 (0%)	4 (0.8%)	−0.8 (−3.7–2.0)	1.000	3 (1.4%)	7 (1%)	0.35 (−1.0–3.0)	0.711
Day of injury								
Weekday	52 (63.4%)	305 (58.9%)	4.5 (−6.9–16)	0.469	139 (63.5%)	436 (63.5%)	0.09 (−7.2–7.4)	1.000
Weekend	30 (36.6%)	213 (41.1%)	−4.5 (−6.9–16)	0.469	80 (36.5%)	250 (36.4%)	0.09 (−7.2–7.4)	1.000
Time of injury								
7 AM–3 PM	20 (24.4%)	122 (23.5%)	0.8 (−9.1–10.7)	0.890	63 (28.8%)	146 (21.3%)	7.5 (1.1–13.9)	**0.027***
3 PM–11 PM	34 (41.5%)	214 (41.3%)	0.1 (−11.3–11.6)	1.000	105 (47.9%)	285 (41.5%)	6.4 (−1.1–13.9)	0.100
11 PM–7 AM	28 (34.1%)	182 (35.1%)	−1.0 (−10.1–12.1)	0.901	51 (23.3%)	255 (37.2%)	−13.9 (6.7–21.1)	**0.0002***
Season of injury								
Winter	18 (21.9%)	85 (16.4%)	5.5 (−3.2–14.3)	0.211	63 (28.8%)	126 (18.4%)	10.4 (4.2–16.6)	**0.002***
Spring	23 (28%)	155 (30%)	−1.9 (−8.8–12.5)	0.795	45 (20.5%)	182 (26.5%)	−6 (−0.6–12.6)	0.774
Summer	19 (23.2%)	150 (29%)	−5.8 (−4.7–16.3)	0.355	59 (26.9%)	225 (32.8%)	−5.8 (−1.2–12.9)	0.112
Autumn	22 (26.8%)	128 (24.7%)	2.1 (−8–12.2)	0.682	52 (23.7%)	153 (22.3%)	1.4 (−4.9–7.8)	0.644

Categorical variables are expressed as count (N) and percentage and continuous variables are expressed as median and interquartile range (IQR); CI, confidence interval; ALS, advanced life support; BLS., basic life support; EMS, emergency medical services; * and bold values = $p < 0.05$.

Table 5
Comparison of trauma activations with complete/accurate vs. incomplete/inaccurate pre-notification information.

Variable	Tier 1 trauma activations				Tier 2 trauma activations			
	Complete/accurate pre-notification information (n = 82) N (%) or median (IQR)	Incomplete/inaccurate pre-notification information (n = 518) N (%) or median (IQR)	Difference (95% CI)	p value	Complete/accurate pre-notification information (n = 219) N (%) or median (IQR)	Incomplete/inaccurate pre-notification information (n = 686) N (%) or median (IQR)	Difference (95% CI)	p value
Blunt trauma	42 (51.2%)	308 (59.4%)	−8.2 (−3.2–19.7)	0.185	198 (90.4%)	647 (94.3%)	−3.9 (0.1–7.7)	0.060
Fall	15 (18.3%)	109 (21%)	−2.7 (−6.7–12.2)	0.660	72 (32.9%)	229 (33.4%)	−0.5 (−6.7–7.7)	0.934
MVA	15 (18.3%)	83 (16%)	2.3 (−6.3–10.9)	0.630	62 (28.3%)	176 (25.6%)	2.6 (−4.0–9.3)	0.429
Assault	6 (7.3%)	29 (5.6%)	1.7 (−3.7–7.2)	0.610	16 (7.3%)	91 (13.3%)	−6.0 (1.0–10.9)	**0.016***
Pedestrian struck	5 (6.1%)	72 (13.9%)	−7.8 (−0.07–12.5)	0.051	41 (18.7%)	133 (19.4%)	−0.7 (−5.3–6.7)	0.922
Other	1 (1.2%)	15 (2.9%)	−1.7 (−3.8–3.8)	0.710	7 (3.2%)	18 (2.6%)	0.6 (−1.9–3.1)	0.639
Penetrating trauma	40 (48.8%)	207 (40%)	8.8 (−2.6–20.3)	0.148	21 (9.6%)	39 (5.7%)	3.9 (0.1–7.7)	0.060
Assault – GSW	17 (20.7%)	99 (19.1%)	1.6 (−7.6–10.8)	0.763	12 (5.5%)	22 (3.2%)	2.3 (−0.6–5.2)	0.151
Assault – SW	22 (26.8%)	101 (19.5%)	7.3 (−2.1–16.7)	0.141	7 (3.2%)	14 (2%)	1.2 (−1.1–3.4)	0.310
Other	1 (1.2%)	7 (1.3%)	−0.1 (−5.3–1.9)	1.000	2 (0.9%)	3 (0.4%)	0.5 (−0.6–2.8)	0.599
Unknown mechanism of injury	0 (0%)	3 (0.6%)	−0.6 (−3.9–1.7)	1.000	0 (0%)	0 (0%)	0 (−0.6–1.7)	1.000
ED LOS (mins)	280 (IQR: 74, 534)	222 (IQR: 77, 407)	58 (−93–9)	0.112	360 (IQR: 248, 529)	367.5 (IQR: 253.8, 542.3)	−7.7 (−15–50)	0.299
Time to first or visit (mins)	115 (IQR: 34, 1062)	228.5 (IQR: 57.5, 1668)	−113.5 (−11–190)	0.130	945 (IQR: 377, 2285)	1458 (IQR: 609.3, 4029)	−512.5 (82, 974)	**0.016***
Direct ED admit to OR (mins)	56.5 (IQR: 34, 108)	69 (IQR: 34, 159.5)	−12.5 (−21–49)	0.661	470 (IQR: 191, 607)	212 (IQR: 103, 349)	258 (−398–67)	0.127
Emergent intubation	20 (24.4%)	174 (33.6%)	−9.2 (−1.7–20.1)	0.101	7 (3.2%)	49 (7.1%)	−3.9 (0.3–7.6)	**0.036***
MTP activation	4 (4.9%)	30 (5.8%)	−0.9 (−6.3–4.7)	**0.024***	1 (0.5%)	1 (0.1%)	0.3 (−0.5–2.4)	0.426
Alcohol use	20 (24.4%)	188 (36.3%)	−11.9 (0.8–23)	**0.045***	47 (21.5%)	233 (34%)	−12.5 (5.5–19.5)	**0.0004***
Drug use	20 (24.4%)	86 (16.6%)	7.8 (−1.1–16.7)	0.088	34 (15.5%)	105 (15.3%)	0.2 (−5.3–5.7)	0.915
Injury severity score (ISS)	5 (IQR: 2, 14)	9 (IQR: 4, 17)	−4 (0–4)	0.075	4 (IQR: 1, 9)	4 (IQR: 1, 9)	0 (0–0)	0.774
ISS ≥ 16	24 (29.3%)	177 (34.2%)	−4.9 (−6.1–15.9)	0.450	24 (10.9%)	74 (10.8%)	0.2 (−4.5–4.9)	1.000
ISS < 16	58 (70.7%)	341 (65.8%)	4.9 (−6.1–15.9)	0.450	195 (89%)	612 (89.2%)	−0.2 (−4.5–4.9)	1.000
ED disposition								
Home	19 (23.2%)	106 (20.5%)	2.7 (−6.7–12.2)	0.561	96 (43.8%)	263 (38.3%)	5.5 (−1.9–12.9)	0.154
Floor	38 (46.3%)	240 (46.3%)	0 (−11.6–11.6)	1.000	104 (47.5%)	349 (50.9%)	−3.4 (−4.2–11)	0.394
ICU	6 (7.3%)	62 (12%)	−4.6 (−2.7–12)	0.263	8 (3.6%)	43 (6.3%)	−2.6 (−0.9–6.1)	0.178
OR	14 (17.1%)	50 (9.6%)	7.4 (−0.02–14.6)	0.053	7 (3.2%)	15 (2.2%)	1.0 (−1.3–3.3)	0.449
Psychiatry	1 (1.2%)	3 (0.6%)	0.6 (−0.9–6.0)	0.445	1 (0.5%)	2 (0.3%)	0.2 (−0.7–2.3)	0.565
Left AMA	1 (1.2%)	5 (1%)	0.2 (−1.4–5.6)	0.588	0 (0%)	12 (1.7%)	−1.7 (−0.1–3.0)	0.081
Mortality	3 (3.6%)	52 (10%)	−6.4 (−0.6–10.1)	**0.044***	1 (0.5%)	0 (0%)	0.5 (−0.2–2.5)	0242
Transferred	0 (0%)	0 (0%)	0 (−0.7–4.5)	1.000	2 (0.9%)	2 (0.3%)	0.6 (−0.4–3.0)	0.248

Categorical variables are expressed as count (N) and percentage and continuous variables are expressed as median and interquartile range (IQR); CI, confidence interval; MVA, motor vehicle accident; GSW, gunshot wound; SW, stab wound; ED, emergency department; LOS, length of stay; OR, operating room; MTP, massive transfusion protocol; ICU, intensive care unit; AMA, against medical advice; * and bold values = $p < 0.05$.

Table 6
Comparison of tier 1 trauma activations under-activated due to wrong/missing information provided by EMS/dispatcher vs. tier 1 activations with accurate information.

Outcome	Correct activation (n = 82) N (%) or median (IQR)	Under-activation (n = 15) N (%) or median (IQR)	Difference (95% CI)	ODDS ratio (95% CI)	p value
ED length of stay (mins)	241 (IQR: 74, 500)	161 (IQR: 64, 241)	80 (−226–23)	–	0.146
Time to operating room (mins)	98 (IQR: 34, 1050)	1094 (IQR: 38.5, 4496)	−995.5 (−59–1973)	–	0.234
Emergent intubation	20 (24.4%)	10 (66.6%)	−42.3 (15.3–62.1)	0.2 (0.05–0.5)	**0.002***
MTP activation	4 (4.9%)	2 (13.3%)	−8.5 (−3.4–33.2)	0.3 (0.05–2.0)	0.231
Alcohol use	20 (24.4%)	6 (40%)	−15.6 (−7.0–41.1)	0.5 (0.1–1.5)	0.219
Drug use	20 (24.4%)	2 (13.3%)	11.1 (−14.8–25.1)	2.1 (0.4–10.1)	0.508
Injury severity score (ISS)	7 (IQR: 2, 16)	10 (IQR: 4, 25)	−3 (0–9)	–	0.123
ISS ≥ 16	24 (29.3%)	6 (40%)	−10.7 (−14.7–36.2)	0.6 (0.2–1.9)	0.544
ISS < 16	58 (70.7%)	9 (60%)	10.7 (−14.7–36.2)	1.6 (0.5–5.0)	0.544
ED disposition					
Home	19 (23.2%)	0 (0%)	23.2 (1.3–33.4)	9.5 (0.5–166.6)	**0.037***
Floor	38 (46.3%)	5 (33.3%)	13 (−14–34.1)	1.7 (0.5–5.5)	0.408
Intensive care unit	6 (7.3%)	6 (40%)	−32.7 (14.6–50.8)	0.1 (0.03–0.4)	**0.003***
Operating room	14 (17.1%)	3 (20%)	−2.9 (−13.2–29)	0.8 (0.2–3.3)	0.723
Psychiatry	1 (1.2%)	0 (0%)	1.2 (−19.2–6.6)	0.6 (0.02–14.7)	1.000
Left against medical advice	1 (1.2%)	0 (0%)	1.2 (−19.2–6.6)	0.6 (0.02–14.7)	1.000
Mortality	3 (3.6%)	1 (6.6%)	−3.0 (−5.5–26.3)	0.5 (0.05–5.5)	0.495

Categorical variables are expressed as count (N) and percentage and continuous variables are expressed as median and interquartile range (IQR); CI, confidence interval; ED, emergency department; MTP, massive transfusion protocol; * and bold values = $p < 0.05$.

Incorrect information from EMS resulted in 20 (1.7%) patients being under-activated, while no pre-notification from EMS resulted in 593 (27.1%) patients being under-activated. ACSCOT recommends an under-triage rate of <5%, which takes into account the injury severity score of the patient. Based on the ACSCOT's Cribari Method of calculating under-triage rate, the EMS's under-triage rate as a result of incorrect information was 45%, which is unacceptable according to ACSCOT's standards. This does not take into account the additional 56 patients with no pre-hospital notification that had an ISS ≥16. The inclusion of these patients would adjust the under-triage rate to 10.6%, which is still double the benchmark rate. The ACSCOT's over and under triage guidelines and the Cribari Method of calculating the triage rate were designed to determine in-hospital over and under triage. However, when applied to the EMS they highlight the need to have a better pre-hospital notification system.

There were some limitations to this prospective study. This study was limited to a specific geographic region and a single trauma center therefore, the results may not be generalizable or applicable to other centers. Human error by ED nursing staff when recording the pre-hospital information on the notification forms cannot be ruled out. However, notification nurses were instructed to meticulously record all information relayed directly from EMS crews or via a dispatcher and to ask for omitted information. Factors such as a language barrier, lack of patient cooperation, and alcohol and drug use may have affected the ability of EMS to obtain the necessary information from the patient. Alcohol use and drug use was taken into consideration, the other factors were not. Estimated time of arrival was not included in this study; however it has been evaluated in other studies. Direct (EMS) vs. indirect (dispatcher) communication with hospital staff was not initially included on our pre-hospital notification form; therefore it was excluded from the study as it was not collected for all trauma activations.

5. Conclusions

This prospective study demonstrated that EMS crews provide inaccurate or incomplete information during pre-hospital notification calls or do not provide any pre-hospital notification at all. Even though, this inaccurate/incomplete information resulted in a change in trauma level activation in a small percentage of patients, it translated into a significantly high under-triage rate when injury severity was considered. Incorrect mechanism of injury, incorrect site of injury, and missing GCS/AVPU score were the top reasons for the change in trauma activation level. Training in these areas may alleviate this problem, especially for BLS crews who were more likely to make these mistakes. For our internal EMS staff, it should be simple to reinforce the criteria for pre-hospital notification and trauma activation. For external EMS companies, they will have to be contacted to initiate a plan for a better pre-hospital notification system. Maintaining compliance with both under and over triage benchmark rates is not only essential for resource utilization but also for minimizing morbidity and mortality rates. Optimizing pre-hospital notification to ensure appropriate triage should aid in compliance with benchmark levels of under and over triage.

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Author contributions

Study concept and design – MKJ, SWL, JSR, GKD.
Data collection – MKJ, LAC, RMS, AJN.
Data analysis & interpretation – MKJ, SWL.
Manuscript preparation & critical revision – MKJ, SWL, GKD.

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