Care of injured children compared to adults at district and regional hospitals in Ghana and the impact of a trauma intake form: A stepped-wedge cluster randomized trial

Adam Gyedu, MD MPH
Department of Surgery, School of Medicine and Dentistry, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
University Hospital, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
Email: drgyedu@gmail.com

Adamu Issaka, MD
Department of Surgery, School of Medicine, University for Development Studies, Tamale, Ghana

Anthony Baffour Appiah, Mphil
Ghana Field Epidemiology and Laboratory Training Program, School of Public Health, University of Ghana, Legon, Accra, Ghana.

Peter Donkor, MDsc
Department of Surgery; School of Medicine and Dentistry; Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Charles Mock, MD PhD
Department of Surgery, University of Washington, Seattle, WA, USA
Harborview Injury Prevention and Research Center, Seattle, WA, USA

Corresponding author:
Adam Gyedu
Department of Surgery
School of Medicine and Dentistry, KNUST
Private Mail Bag, University Post Office
Kumasi, Ghana

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Abstract

Background: This study aimed to determine the effectiveness of a standardized trauma intake form (TIF) to improve achievement of key performance indicators (KPIs) of initial trauma care among injured children, compared to adults, at non-tertiary hospitals in Ghana.

Methods: A stepped-wedge cluster randomized trial was performed with research assistants directly observing the management of injured patients before and after introducing the TIF at emergency units of 8 non-tertiary hospitals for 17.5 months. Differences in outcomes between children and adults in periods before and after TIF introduction were determined with multivariable logistic regression. Differences in outcomes among children after TIF introduction were determined using generalized linear mixed regression.

Results: Management of 3,889 injured patients was observed; 757 (19%) were children <18 years. Trauma care KPIs at baseline were lower for children compared to adults. Improvements in primary survey KPIs were observed among children after TIF introduction. Examples include airway assessment [279 (71%) to 359 (98%); adjusted odds ratio (AOR):74.42, p=0.005)] and chest examination [225 (58%) to 349 (95%); AOR 53.80, p=0.002)]. However, despite these improvements, achievement of KPIs was still lower compared to adults. Examples are pelvic fracture evaluation [children:295 (80%) vs adults:1,416 (88%), AOR: 0.56, p=0.001] and respiratory rate assessment (children:310 (84%) vs adults:1,458 (91%), AOR: 058, p=0.030).

Conclusions: While the TIF was effective in improving most KPIs of pediatric trauma care, more targeted education is needed to bridge the gap in quality between pediatric and adult trauma care at non-tertiary hospitals in Ghana and other low- and middle-income countries.

Keywords: Pediatric, Trauma care, Trauma Intake Form, Checklist, Non-tertiary hospital, Ghana

Type of Study: Stepped-wedged cluster randomized controlled trial

Level of Evidence: I

Abbreviations used

EU	Emergency Unit
EHSP	Emergency Unit Health Service Provider
KPI	Key Performance Indicator
LMICs	Low- And Middle-Income Countries
RA	Research Assistant
TIF	Trauma Intake Form

1. Introduction

Children contribute significantly to the global injury burden, with one-third of the over 700 million new injuries reported worldwide in 2019 accounted for by children under 19 years, according to the Global Burden of Disease database [1]. Over 80% of injuries occurring among 0-19 year-olds in 2019 were in low- and middle-income countries (LMICs) and accounted for more than 49 million disability-adjusted life years [1]. A key aspect in efforts to reduce this large injury burden lies in strengthening care of injured children [2].

Strengthening pediatric trauma care involves improving human and physical resources for care, which are inadequate in many LMICs [3, 4]. Additionally, trauma care in LMIC hospitals is not usually organized by trauma teams, [5-7] and at smaller non-tertiary hospitals care is largely provided by non-specialists [8]. Differences in quality of trauma care for children and adults in these LMIC non-tertiary hospitals are largely unknown. While LMICs steadily work to improve the needed resources for trauma care in general, improving the process of care provides a low-cost opportunity to reduce the burden of injuries overall, and especially among children [9].

A previous study on the achievement of key performance indicators (KPIs) for trauma care at district (first-level) and regional (second-level) hospitals in Ghana concluded that care at these hospitals could be improved with more systematic approach that could be promoted with the use of a trauma intake form [10]. In this study, we sought to determine the achievement of KPIs of care at such hospitals among injured children compared to adults and also to determine the effectiveness of, a quality improvement initiative, a standardized trauma intake form, to improve KPIs of initial care for injured children.

2. Methods

2.1 Setting

Ghana is a lower-middle-income country with a population of 31 million [11]. Trauma care is organized at three levels: district (first-level), regional (referral), and tertiary hospitals. District hospitals provide basic trauma care and are staffed by nurses, general doctors, and/or physician assistants, and occasionally by specialists. Regional hospitals have specialists (e.g., general and orthopedic surgeons) and tertiary hospitals offer advanced trauma care [8, 12]. Essential trauma care resources, such as airway supplies, chest tubes, and diagnostic imaging (e.g., x-ray, ultrasonography) are frequently lacking at district hospitals, with slight improvement in availability at regional hospitals. All levels of Ghanaian hospitals lack systematic quality improvement processes for monitoring trauma care [13].

2.2 Study Design

We performed a pragmatic, stepped-wedge, randomized clinical trial with the trauma intake form (TIF) as a quality improvement intervention to improve initial assessment and care provided by emergency unit (EU) health service providers (EHSP) in six district and two regional hospitals. These hospitals were purposively selected for their adequate average volume of injured patients (≥75 patients per month) (Supplementary table). The TIF was designed as a checklist that also provides real-time clinical decision support prompts to promote adherence to the ABCDE approach to initial trauma care (Supplementary material). Checklist items on the TIF represented KPIs for initial trauma care and were derived from the World Health Organization's Trauma Care Checklist and audit filters considered context-appropriate for non-tertiary hospitals in LMICs and developed through a Delphi process with global experts with trauma care expertise and/or working experience in LMIC settings [9, 14].

2.3 Sample Size Estimation

Research assistants (RAs), with bachelors level education, were trained by the principal investigator in a two-day session after which they were stationed at study hospitals for 8 hours daily. Study hospitals were non-tertiary hospitals that manage at least 75 injured patients per month. With RAs present for one-third of the day at emergency units of study hospitals, patient enrolment was expected at 25 per hospital per month for a total of 3,500 patients enrolled across the 8 hospitals over 17.5 months. Assuming an alpha of 0.05, 50% TIF adherence rate at baseline, and a coefficient of variation of 0.15–0.40, the study had 80% power to detect 8.1–8.6% difference in KPIs [15, 16].

2.4 Study procedures

Data collection occurred from October 2020 to March 2022. Details of the study procedures, including data collection methods have previously been described [10]. Briefly, RAs observed and documented initial assessment and care of injured patients at the 8 hospitals for 3.5 months. The TIF was then introduced to 2 nearby hospitals, through simple random sampling, after training the EHSPs on its use. Sampling was done using STATA'S random number generator. Groups of 2 nearby hospitals were randomized together for ease of study management. The TIF was introduced sequentially to randomly selected groups of 2 hospitals every 3.5 months in a stepped-wedge manner with a total of 5 periods. The RAs were stationed at each EU in rotating 8-hour shifts and they recorded completion of KPIs (e.g., vital signs checked on arrival, chest examination, abdomen examination), or lack thereof, using an observation form that mirrored the TIF.

Direct observations were done without interaction with EHSP or patients and complemented with information from medical records. A KPI was considered as performed if the RA directly observed an EHSP perform it or if it was documented in the medical record or both. For instances where there was no need to perform a given KPI (e.g., chest examination in an isolated foot injury), RAs recorded the KPI as performed if there was indication in the medical record that there was no need for it. Data gathered by the RAs were reviewed daily to assure completeness during the first month after each period of the stepped-wedge and weekly thereafter. Additionally, each RA's work was validated by the PI observing them in action at random twice during the study. Results of the trial for the overall patient population (adults and children combined) have been previously reported [17]. The current study focuses on the care of the injured children.

2.5 Data Analysis

Analyses were performed with Stata 17 (StataCorp, USA). We defined children as patients <18 years old and adults as those ≥18 years. Primary outcomes were performance of KPIs and documentation of data in the patients' medical records. We defined a variable "important clinical data documented" as documentation of all of patient age, sex, injury type, injury intent, injury mechanism, blood pressure, heart rate, and consciousness level (AVPU) at EU arrival. Injury severity score (ISS) was determined for all patients and serious injury defined as ISS ≥9 [18, 19]. Secondary outcomes were complications (any of pneumonia, wound infection, or deep vein thrombosis, as documented in the medical records) and in-hospital mortality.

Analyses included only patients with complete primary outcome data. Children and adult characteristics were compared with Chi-square tests. Differences in outcomes between children and adults in periods before or after TIF introduction were determined with multivariable logistic regression, adjusted for hospitals (cluster) and significantly different variables in bivariate analysis (i.e., sex, injury mechanism and intent, and injury severity). Among children, differences in outcomes before vs. after TIF introduction were estimated using generalized linear mixed regression models with TIF introduction (intervention) as a fixed effect and with adjustment for time periods and injury severity as fixed effects and hospitals (cluster) and time periods as random effects, which are standard methods for analysis of stepped-wedge studies [20, 21]. Data were analyzed on intention-to-treat basis. All patients treated in hospitals at which the TIF had been introduced were considered in the intervention arm regardless of whether the TIF was utilized in their management.

2.6 Ethics

The Committee for Human Research and Publication Ethics of Kwame Nkrumah University of Science and Technology approved the study (CHRPE/AP/142/20). Written informed consent was obtained from EHSPs to be observed. The study was pre-registered at clinicaltrials.gov (NCT04547192).

3. Results

Four thousand one hundred and fifty-eight patients were assessed for eligibility into the study. After exclusion of non-trauma patients, patients with missing ages and those with incomplete primary outcome data, 3,889 injured patients were included for analysis (Figure 1)

3.1 Patient characteristics

There were 757 (19%) children <18 years with a mean age of 10 $\pm$ 5 (SD) years. More female children (262; 35%) were injured compared to adults (746; 24%) (p <0.001). Children presented with more penetrating injuries [183 (24%) vs 613 (20%), p <0.001] and burns [53 (7%) vs 40 (1%), p <0.001] than adults (Table 1). Injuries were more unintentional among children [711 (94%) vs 2,732 (87%), p <0.001].

3.2 Initial assessment and management of injury

Before TIF introduction, KPIs of initial assessment and management of injury were achieved to a lesser extent for children compared to adults. Examples include assessments for respiratory rate (47% vs 63%, adjusted odds ratio (AOR): 0.52, p <0.001) and oxygen saturation (49% vs 59%, AOR: 0.70, p=0.007) at EU arrival, examination for external bleeding

(47% vs 60%, AOR: 0.65, p=0.006) and evaluation for intra-abdominal bleeding (24% vs 60%, AOR: 0.54, p <0.001), and documentation of important clinical data (22% vs 65%, AOR: 0.16 p <0.001) (Table 2).

3.3 Impact of TIF on KPIs of initial assessment and management of injury among children

After TIF introduction, improvements in KPIs of trauma care were observed among children (Tables 3 and 4). Examples of significant improvements include airway assessment (71% to 98%; AOR:74.42, p=0.005) and chest examination (58% to 95%; AOR 53.80, p=0.002), which improved by >10% and had a compliance of ≥90% after TIF introduction. KPIs which had >10% improvement and 80%–89% compliance after TIF introduction included examination for external bleeding (47% to 89%; AOR: 18.83, p=0.008), assessment for intra-abdominal bleeding (24% to 83%; AOR: 136.56, p<0.001), and spine immobilization for road traffic crash or fall victims (9% to 80%; AOR: 714.19, p< 0.001). Tetanus consideration for bites, burns, and lacerations saw >10% improvement but compliance after TIF introduction was <80% (58% to 73%; AOR: 5.86, p=0.010). Recording of examination findings and consideration of analgesics had >90% compliance before and after TIF introduction. Complication and mortality rates among children did not change after TIF introduction (Table 3).

After TIF introduction, achievement of KPIs of care were still lower among children compared to adults. Examples include respiratory rate assessment at EU arrival (84% vs 91%, AOR: 0.58, p=0.030), chest examination (95% vs 97%, AOR: 0.52, p<0.001), examination for external bleeding (89% vs 95%, AOR: 0.51, p <0.001), intra-abdominal bleeding assessment (83% vs 90%, AOR: 0.55, p=0.009), and consideration of tetanus for bites, burns, and lacerations (73% vs 91%, AOR: 0.30, p <0.001). Documentation of important clinical data was still lower among children (31% vs 89%, AOR: 0.05, p <0.001) (Table 5). Complication and mortality rates were similar between children and adults either before or after TIF introduction (Tables 2 and 5).

4. Discussion

This study aimed to compare achievement of key performance indicators (KPIs) of initial care of injured children at Ghanaian non-tertiary hospitals to that of adults and determine improvements after introduction of a trauma intake form (TIF). There was significantly lower achievement of initial trauma care KPIs among children prior to TIF introduction compared to adults. Although most primary assessment KPIs improved among children after TIF introduction, the performance of KPIs was still lower than that observed among adults. These findings emphasize the need to improve assessment and care for injured children in the emergency department setting in LMICs. The findings also demonstrate the effectiveness of checklist-based initiatives, such as the TIF, to provide improvements in care.

Our study appears to be the most comprehensive to date in comparing trauma care KPIs for children vs. adults at the emergency department and confirms the findings of previous studies. Data from the German nationwide trauma registry showed that fewer injured children received catecholamines, fluid resuscitation, chest tube insertions and external stabilization of fractures than adults at the emergency department [22]. Similarly, 68% of infants had complete documentation of vital signs (respiratory rate, blood pressure, and heart rate) among injured patients transported by ground emergency medical services in

Pennsylvania; the rate increased with age to 98% among adults [23]. Among children with moderate to severe traumatic brain injury presenting to a level 1 pediatric trauma center, 31% did not have blood pressure recorded and 34% did not have oxygenation recorded in the prehospital setting or at the emergency department [24]. Likewise, emergency medical service providers reported not measuring Glasgow Coma Scale for 6%, blood pressure for 16%, and respiratory rate for 8% of injured children requiring transport to a 3 pediatric trauma centers in the United States [25].

The discrepancy in achieving trauma care KPIs between children and adults may be due to a variety of factors. Despite accounting for majority of global pediatric trauma, most LMICs do not have designated centers specialized in pediatric trauma care and care for injured children occurs at hospitals and by providers who also cater for adults [26]. Pediatric trauma care requires equipment and skillsets different from those regularly used for adults, the lack of which may contribute to low achievement of initial care KPIs. Pediatric-sized blood pressure cuffs were reportedly available to less than half of those who needed it at Ghanaian district hospitals, while pediatric size cervical collars, portable X-rays and focused abdominal sonography for trauma were absent at both district and regional hospitals [3]. Additionally, emergency unit health service providers practicing at LMIC non-tertiary hospitals may be exposed to less continuing education in pediatric trauma care, possibly leading to a difficulty in effectively triaging and managing injured children. Lack of appropriate training was responsible for lack of trauma care items for children in 4%–18% of Ghanaian hospitals [3]. Having pediatric trauma care integrated into general medical, postgraduate surgical, and emergency medicine training curricula as well as improvements in relevant continuous education would provide the necessary skillset for non-specialists managing injured children at the more proximate non-tertiary hospitals. Lack of formal pediatric trauma training may also be overcome with specially curated courses such as conducted by Children's Medical Services International in Jamaica [27]. The findings of the current study should also be put into perspective with the literature comparing trauma care that children receive at adult trauma centers vs. pediatric trauma centers in high-income countries. It has been shown in most, but not all, studies that care and outcomes are better at pediatric trauma centers. This has led to a push to have more centers verified as pediatric trauma centers, including hospitals that provided mixed care to both adults and children [28, 29].

Quality improvement initiatives have been shown to improve trauma care processes [2]. A telesimulation teaching model was used to improve physician confidence in inserting intraosseous needles for children in Botswana [30]. Similarly, a quality improvement program in Canada reduced abdominopelvic tomography rates among injured children at low risk for intraabdominal injury without missing cases of clinically significant injury [31]. An important observation in the current study was the impact of the TIF on achieving primary survey KPIs among injured children, most of whom improved >10% with at ≥80% achievement after TIF introduction. The observed improvement in these particular KPIs is important as their non-performance could directly contribute to poor patient outcomes. The lack of significant improvement (22% before; 31% after) in documentation of important clinical data after TIF introduction was due to low rate of blood pressure measurements among children, likely due to absence of appropriately-sized blood pressure cuffs especially at district hospitals. This is in contrast to adult patients in whom this particular KPI improved from 65% to 89%. Complete documentation of vital signs have been reported to be highly variable among children, [32] and failure of blood pressure measurement has been found as the primary driver of incomplete vital signs documentation [23]. This lack of documentation may not necessarily imply that vital signs, e.g., blood pressure, were not obtained. However, from a quality improvement perspective lack of documentation (whether from a lack of performance or documentation) hinders the ability to assess pediatric trauma care.

Bias in this study was mitigated in several ways [33]. Recruitment bias was avoided by obtaining consent from EHSPs to be observed. This allowed inclusion of all injured patients arriving at the EU. Performance bias was minimized by not interfering with EHSP patient management either before or after TIF introduction. Within-cluster contamination was minimized by exposing EHSPs to the TIF only after their hospital was randomized for TIF introduction and cluster allocation bias was avoided by exposing all the hospitals to the TIF with their order of exposure determined randomly. The study had some limitations that needs addressing. Firstly, EHSP behavior could have improved due to a Hawthorne effect of having observers at the EUs. However, the observers were present for several months prior to TIF introduction and a possible Hawthorne effect would be greatest during the before period. Hence, improvements found after TIF introduction were likely even more meaningful than found by the study. Nonetheless, further work is needed to guarantee continued implementation of the TIF at enrolled hospitals in the absence of observers to inform expansion to other hospitals. Secondly, 188 patients were excluded from analysis on account of missing age and it is difficult to judge the impact of their exclusion on our results. Thirdly, the study was not specifically powered to detect mortality differences after TIF introduction. Hence, our inability to observe a mortality reduction among children after TIF introduction may only be coincidental. Fourth, injury severity scores are likely underestimated when compared to scores from high-income countries due to lower imaging capabilities in LMIC hospitals. However, because this under-assessment applies to both phases of the study, it is unlikely to bias the before vs after results. Despite these limitations, this study has the strengths of using direct observations and a large sample size with sufficient power to detect improvements in care processes of the injured. The TIF's effectiveness serves as the basis for its wider implementation in collaboration with health service managers.

5. Conclusion

Our direct observation of health provider practices at the emergency units of non-tertiary hospitals in a LMIC setting confirm the lower level of pediatric trauma care compared to adults. Although the trauma intake form was effective in improving most KPIs of pediatric trauma care, more targeted education is needed for non-specialist trauma care providers at smaller non-tertiary hospitals in LMICs. This would help bridge the quality gap between pediatric and adult trauma care at these hospitals where most LMIC children are likely to receive initial care for injury.

Declaration of interest

The authors declare no conflict of interest

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Data availability statement

The datasets generated during and/or analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

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Table and figure legend

Table 1. Characteristics of injured patients presenting to emergency units (EU) of select Ghanaian district and regional hospitals (N=3,889)

Table 2. Assessment and management of injured patients presenting to emergency unit of select Ghanaian district and regional hospitals before trauma intake form introduction (N=1,912)

Table 3. Achievement of trauma care key performance indicators among injured children presenting to emergency unit of select Ghanaian district and regional hospitals (N=757)

Table 4. Improvements in KPIs after TIF introduction among all injured children

Table 5. Assessment and management of injured patients presenting to emergency unit of select Ghanaian district and regional hospitals after trauma intake form introduction (N=1,977)

Figure 1: Trial CONSORT flow diagram

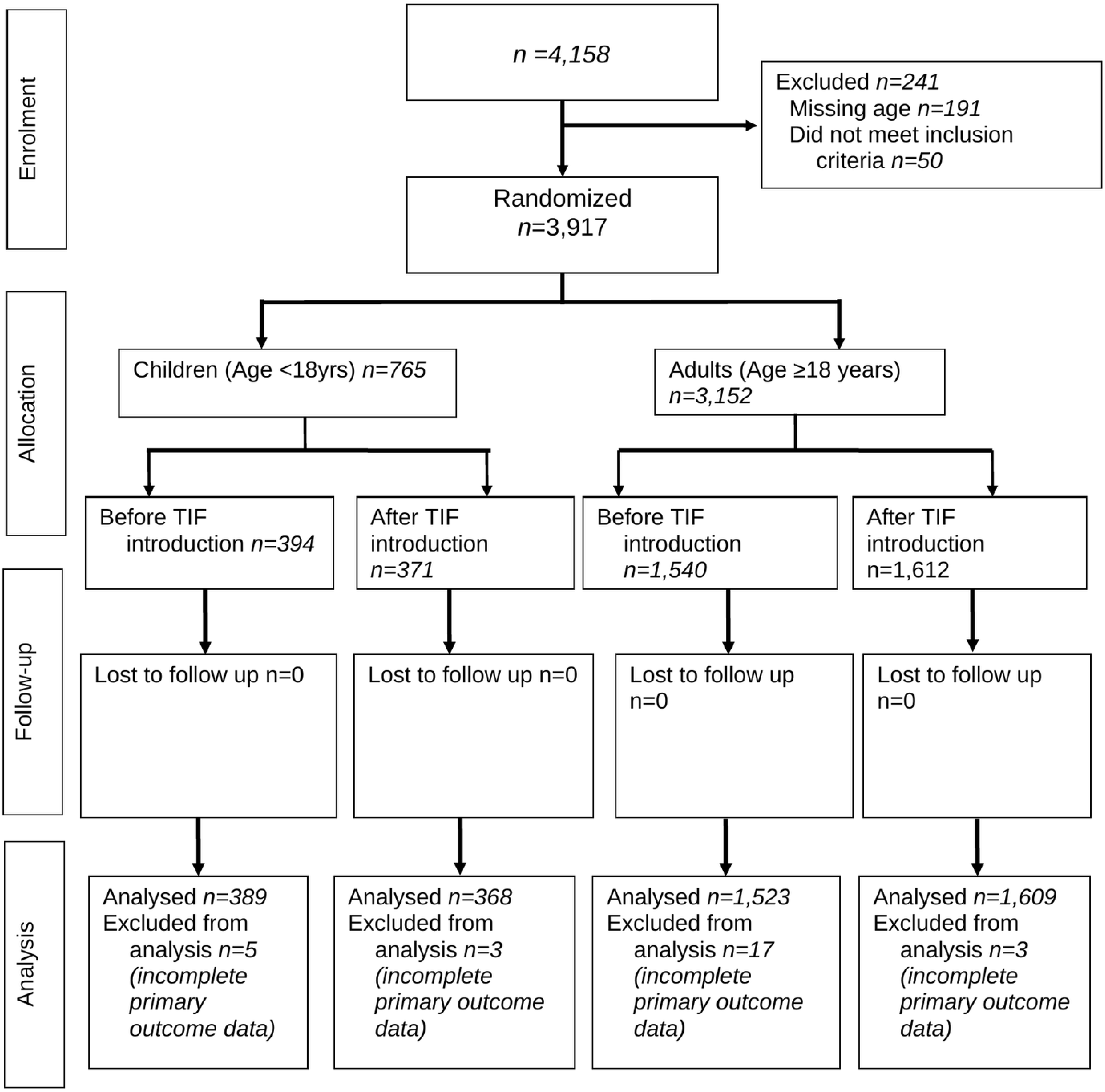

Figure 1: Trial CONSORT flow diagram

Table 1. Characteristics of injured patients presenting to emergency units (EU) of select Ghanaian district and regional hospitals (N=3,889)

	Children (<18 years) (n=757)		Adults (≥18) (n=3,132)		
	N	(%)	N	(%)	p-value
Sex					
Male	494	(65)	2,383	(76)	**<0.001**
Female	262	(35)	746	(24)	
Missing	1	(0.1)	3	(0.1)	
Age, Mean (SD), Years	10	(5)	34	(13)	**<0.001**
Mechanism of injury					
Blunt	521	(69)	2,475	(79)	**<0.001**
Penetrating	183	(24)	613	(20)	
Burns	53	(7)	40	(1)	
Missing	0	(0)	4	(0.1)	
Intent					
Unintentional	711	(94)	2,732	(87)	**<0.001**
Intentional	36	(5)	361	(12)	
Unknown/Missing	10	(1)	39	(1)	
Consciousness level at EU arrival					
Alert	637	(84)	2,707	(86)	0.887
Responds to verbal stimuli	4	(0.5)	18	(0.6)	
Responds to pain stimuli	30	(4)	108	(3)	
Unresponsive	16	(2)	66	(2)	
Missing	70	(9)	233	(7)	
EU outcome					
Discharged home from EU	491	(63)	1,962	(63)	0.712
Referred in EU	52	(7)	237	(8)	
Died in EU	5	(0.7)	20	(0.6)	
Admitted to hospital	209	(28)	913	(29)	
Discharged home[a]	189	(90)	758	(83)	
Referred[a]	16	(8)	121	(13)	
Died[a]	4	(2)	34	(4)	
Seriously injured	47	(6)	296	(9)	**0.005**

Statistical tests done excluding missing data.
p-values in bold denotes statistical significance.
EU: Emergency Unit
Seriously injured – Injury Severity Score ≥9.
[a]Percentages based on denominator of all admitted patients.

Table 2. Assessment and management of injured patients presenting to emergency unit of select Ghanaian district and regional hospitals before trauma intake form introduction (N=1,912)

	Children (<18 years) (n=389)		Adults (≥18years) (n=1,523)			
	N	(%)	N	(%)	AOR (95% C.I)	p-value
Triage and monitoring						
Mobility at EU arrival assessed	322	(83)	1,367	(90)	0.57 (0.34 – 0.93)	**0.026**
Respiratory rate at EU arrival assessed	181	(47)	959	(63)	0.52 (0.37 – 0.73)	**<0.001**
Temperature at EU arrival assessed	300	(77)	1,229	(81)	0.80 (0.53 – 1.22)	0.309
Oxygen saturation level at EU assessed	191	(49)	893	(59)	0.70 (0.52 – 0.94)	**0.017**
Primary assessment and actions						
Airway assessed	279	(72)	1,134	(74)	0.92 (0.66 – 1.28)	0.622
Chest examined	225	(58)	987	(65)	0.84 (0.63 – 1.12)	0.247
Intravenous line placed	178	(46)	861	(57)	0.66 (0.50 – 0.87)	**0.003**
External bleeding checked for and controlled	182	(47)	919	(60)	0.65 (0.48 – 0.88)	**0.006**
Intra-abdominal bleeding evaluated[a]	93	(24)	913	(60)	0.54 (0.47 – 0.62)	**<0.001**
Pelvic fracture evaluated	76	(20)	520	(34)	0.54 (0.43 – 0.68)	**<0.001**
All distal pulses checked	99	(25)	579	(38)	0.63 (0.43 – 0.91)	**0.014**
Fluid and/or blood requirement considered	156	(40)	787	(52)	0.63 (0.47 – 0.86)	**0.003**
Spine immobilized for RTI or fall victims (n=242 children, 1,109 adults)[b]	21	(9)	224	(20)	0.42 (0.27 – 0.66)	**<0.001**
Splinting of fractures considered (n=51 children, 273 adults)	30	(59)	162	(59)	0.97 (0.49 – 1.94)	0.936
Physical examination findings recorded	373	(96)	1,443	(95)	1.44 (1.11 – 1.88)	**0.005**
Alcohol on breath assessed[c]	50	(13)	362	(24)	0.53 (0.40 – 0.70)	**<0.001**
Total burn surface area estimated (n=22 children, 17 adults)	14	(64)	6	(35)	4.20 (0.80 – 22.02)	0.089
Tetanus considered for bites, burns, lacerations, and abrasions (n=317 children, 1,210 adults)	185	(58)	967	(80)	0.40 (0.29 – 0.54)	**<0.001**
Antibiotic considered (e.g., open fracture)	321	(83)	1,263	(83)	0.98 (0.73 – 1.30)	0.872
Analgesics considered	363	(93)	1,462	(96)	0.52 (0.23 – 1.21)	0.131
Documentation						
Blood pressure	98	(25)	1,176	(77)	0.11 (0.07 – 0.16)	**<0.001**
Heart rate	213	(55)	1,132	(74)	0.42 (0.29 – 0.63)	**<0.001**
Important clinical data documented[d]	87	(22)	996	(65)	0.16 (0.11 – 0.24)	**<0.001**
Complications						
Any complication	3	(0.8)	21	(1.4)	0.53 (0.26 – 1.06)	0.073

Death	5	(1.3)	36	(2)	0.75 (0.29 – 1.97)	0.561

Key performance indicators listed in the table represent elements of the Trauma Intake Form
EU– Emergency Unit; RTI – Road Traffic Injury; EHSP – Emergency Unit Health Service Provider; AOR – Adjusted Odds Ratio (adjusted for patient sex, injury mechanism, injury intent and injury severity score, and hospital (cluster)).
p-values in bold denotes statistical significance.

[a] Internal abdominal bleeding ruled out by any one of: abdominal exam, ultrasound, X Ray, computerized tomography;

[b] Spine immobilization implies use of either cervical collar or backboard; [c] Assessed by smelling the patient's breathe;

[d] Important clinical data documented - all of the following: patient sex, patient age, mechanism of injury, intent of injury, heart rate at EU arrival, blood pressure at EU arrival, consciousness level at EU arrival, and injury type

Table 3. Achievement of trauma care key performance indicators among injured children presenting to emergency unit of select Ghanaian district and regional hospitals (N=757)

	Before TIF introduction (n=389)		After TIF introduction (n=368)			
	N	(%)	N	(%)	AOR	p-value
Triage and monitoring						
Mobility at EU arrival assessed	322	(83)	343	(93)	2.84 (0.65 – 12.35)	0.165
Respiratory rate at EU arrival assessed	181	(47)	310	(84)	4.69 (0.91 – 24.17)	0.065
Temperature at EU arrival assessed	300	(77)	335	(91)	1.55 (0.32 – 7.53)	0.588
Oxygen saturation level at EU assessed	191	(49)	319	(87)	3.41 (1.19 – 9.79)	**0.022**
Primary assessment and actions						
Airway assessed	279	(71)	359	(98)	74.42 (3.58 – 1,548.98)	**0.005**
Chest examined	225	(58)	349	(95)	53.80 (4.51 – 641.26)	**0.002**
Intravenous line placed	178	(46)	338	(92)	33.88 (9.30 – 123.34)	**<0.001**
External bleeding checked for and controlled	182	(47)	326	(89)	18.83 (2.12 – 167.63)	**0.008**
Intra-abdominal bleeding evaluated[a]	93	(24)	304	(83)	136.56 (9.83 – 1,896.93)	**<0.001**
Pelvic fracture evaluated	76	(20)	295	(80)	274.47 (14.97 – 5,030.67)	**<0.001**
All distal pulses checked	99	(25)	319	(87)	1078.58 (33.16 – 35,082.98)	**<0.001**
Fluid and/or blood requirement considered	156	(40)	325	(88)	42.59 (8.78 – 206.75)	**<0.001**
Spine immobilized for RTI or fall victims (n=242 before, 233 after)[b]	21	(9)	186	(80)	714.19 (26.30 – 19,396.75)	**<0.001**
Splinting of fractures considered (n=51 before, 53 after)	30	(59)	37	(86)	2.40 (0.57 – 10.09)	0.232
Physical examination findings recorded	373	(96)	360	(98)	1.40 (26.30 – 19,396.75)	0.718
Alcohol on breath assessed[c]	50	(13)	215	(58)	13,722.50 (116.11 – 621,694)	**<0.001**
Total burn surface area estimated (n=22 before, 28 after)	14	(64)	17	(61)	50.41 (0.07 – 34,301.05)	0.239
Tetanus considered for bites, burns, lacerations, and abrasions (n=317 before, 300 after)	185	(58)	220	(73)	5.86 (1.53 – 22.43)	**0.010**
Antibiotic considered (e.g., open fracture)	321	(83)	314	(85)	4.45 (1.04 – 18.98)	**0.044**
Analgesics considered	363	(93)	359	(98)	6.22 (0.85 – 45.42)	0.072

Documentation						
Blood pressure	98	(25)	120	(33)	1.21 (0.61 – 2.40)	0.587
Heart rate	213	(55)	317	(86)	2.39 (0.74 – 7.72)	0.144
Important clinical data documented[d]	87	(22)	114	(31)	1.41 (0.67 – 2.97)	0.359
Complications						
Any complication	3	(0.8)	3	(0.8)	1.06	1.000[e]
Death	5	(1)	4	(1)	0.78 (0.09 – 6.88)	0.826

Key performance indicators listed in the table represent elements of the Trauma Intake Form
EU– Emergency Unit; RTI – Road Traffic Injury; EHSP – Emergency Unit Health Service Provider; (AOR – Adjusted Odds Ratio (adjusted for time period, injury severity, and hospital (cluster))
p-values in bold denotes statistical significance.

[a] Internal abdominal bleeding ruled out by any one of: abdominal exam, ultrasound, X Ray, computerized tomography;
[b] Spine immobilization implies use of either cervical collar or backboard; [c] Assessed by smelling the patient's breathe;
[d] Important clinical data documented - all of the following: patient sex, patient age, mechanism of injury, intent of injury, heart rate at EU arrival, blood pressure at EU arrival, consciousness level at EU arrival, and injury type.
[e] Bivariate analysis using Fisher's exact test presented, due to non-convergence of logistic regression model.

Table 4. Improvements in KPIs after TIF introduction among all injured children (n=757)

	Key Performance Indicator
>10% improved AND had ≥90% compliance after TIF	Mobility at EU arrival Temperature at EU arrival *Airway assessed** *Chest examined** *iv line placed**
>10% improved AND had 80-89% compliance after TIF	Respiratory rate at EU arrival Heart rate documented Splinting of fractures considered *Intraabdominal bleeding evaluated** *Pelvic fracture evaluated** *All distal pulses checked** *Fluid and /or blood requirement considered** *Spine immobilized for RTI or fall victims** *External bleeding checked and controlled** *Oxygen saturation at EU arrival**
>10% improved BUT still <80% compliance after TIF	*Alcohol on breath assessed** *Tetanus considered for bites, burns, lacerations, and abrasions**
Already > 90% compliance (before and after)	Physical examination findings recorded Analgesics considered
Not improved by more than 10% AND < 90% compliance: after TIF	Blood pressure documented Important clinical data documented

* Improvement in key performance indicator is statistically significant ($p < 0.05$)

Table 5. Assessment and management of injured patients presenting to emergency unit of select Ghanaian district and regional hospitals after trauma intake form introduction (N=1,977)

	Children (<18 years) (n=368)		Adults (≥18) (n=1,609)			
	N	(%)	N	(%)	AOR (95% C.I)	p-value
Triage and monitoring						
Mobility at EU arrival assessed	343	(93)	1,526	(95)	0.76 (0.42 – 1.38)	0.369
Respiratory rate at EU arrival assessed	310	(84)	1,458	(91)	0.58 (0.35 – 0.95)	**0.030**
Temperature at EU arrival assessed	335	(91)	1,513	(94)	0.67 (0.39 – 1.13)	0.129
Oxygen saturation level at EU assessed	319	(87)	1,453	(90)	0.73 (0.47 – 1.14)	0.166
Primary assessment and actions						
Airway assessed	359	(98)	1,588	(99)	0.59 (0.25 – 1.44)	0.249
Chest examined	349	(95)	1,567	(97)	0.52 (0.37 – 0.75)	**<0.001**
Intravenous line placed	338	(92)	1,532	(95)	0.51 (0.29 – 0.88)	**0.016**
External bleeding checked for and controlled	326	(89)	1,521	(95)	0.51 (0.38 – 0.69)	**<0.001**
Intra-abdominal bleeding evaluated[a]	304	(83)	1,444	(90)	0.55 (0.35 – 0.86)	**0.009**
Pelvic fracture evaluated	295	(80)	1,416	(88)	0.56 (0.40 – 0.79)	**0.001**
All distal pulses checked	319	(87)	1,508	(94)	0.49 (0.30 – 0.79)	**0.003**
Fluid and/or blood requirement considered	325	(88)	1,508	(94)	0.47 (0.35 – 0.62)	**<0.001**
Spine immobilized for RTI or fall victims (n=233 children, 1,178 adults)[b]	186	(80)	1,033	(88)	0.55 (0.45 – 0.68)	**<0.001**
Splinting of fractures considered (n=43 children, 269 adults)	37	(86)	252	(94)	0.53 (0.32 – 0.87)	**0.012**
Physical examination findings recorded	360	(98)	1,576	(98)	0.84 (0.48 – 1.47)	0.532
Alcohol on breath assessed[c]	215	(58)	1,164	(72)	0.54 (0.38 – 0.75)	**<0.001**
Total burn surface area estimated (n=28 children, 23 adults)	17	(61)	19	(83)	0.38 (0.09 – 1.60)	0.187
Tetanus considered for bites, burns, lacerations, and abrasions (n=300 children, 1,307 adults)	220	(73)	1,188	(91)	0.30 (0.20 – 0.47)	**<0.001**
Antibiotic considered (e.g., open fracture)	314	(85)	1,533	(95)	0.30 (0.21 – 0.41)	**<0.001**
Analgesics considered	359	(98)	1,608	(99.9)	0.03 (0.01 – 0.06)	**<0.001**
Documentation						
Blood pressure	120	(33)	1,516	(94)	0.03 (0.01 – 0.08)	**<0.001**
Heart rate	317	(86)	1,509	(94)	0.43 (0.28 – 0.67)	**<0.001**
Important clinical data documented[d]	114	(31)	1,428	(89)	0.05 (0.02 – 0.11)	**<0.001**

Complications						
Any complication	3	(0.8)	2	(0.1)	2.30 (0.59 – 8.92)	0.228
Death	4	(1)	18	(1)	1.42 (0.53 – 3.85)	0.487

Key performance indicators listed in the table represent elements of the Trauma Intake Form
EU– Emergency Unit; RTI – Road Traffic Injury; EHSP – Emergency Unit Health Service Provider; AOR – Adjusted Odds Ratio (adjusted for patient sex, injury mechanism, injury intent and injury severity score, and hospital (cluster)).
p-values in bold denotes statistical significance.
[a] Internal abdominal bleeding ruled out by any one of: abdominal exam, ultrasound, X Ray, computerized tomography; [b] Spine immobilization implies use of either cervical collar or backboard; [c] Assessed by smelling the patient's breathe; [d] Important clinical data documented - all of the following: patient sex, patient age, mechanism of injury, intent of injury, heart rate at EU arrival, blood pressure at EU arrival, consciousness level at EU arrival, and injury type;