Published in final edited form as:

World J Surg. 2020 November ; 44(11): 3643–3650. doi:10.1007/s00268-020-05683-z.

Preventable Trauma Deaths and Corrective Actions to Prevent Them: A 10-Year Comparative Study at the Komfo Anokye Teaching Hospital, Kumasi, Ghana

Dominic Konadu-Yeboah¹, Kusi Kwasi¹, Peter Donkor², Senyo Gudugbe¹, Ossei Sampene³, Augustus Okleme², Frank Nketiah Boakye², Maxwell Osei-Ampofo⁴, Helena Okrah⁵, Charles Mock⁶

¹Directorate of Trauma and Orthopaedics, Komfo Anokye Teaching Hospital, Kumasi, Ghana

²Department of Surgery, Komfo Anokye Teaching Hospital, Kumasi, Ghana

³Department of Pathology, Komfo Anokye Teaching Hospital, Kumasi, Ghana

⁴Directorate of Emergency Medicine, Komfo Anokye Teaching Hospital, Kumasi, Ghana

⁵Department of Anaesthesia, Komfo Anokye Teaching Hospital, Kumasi, Ghana

⁶Department of Surgery, University of Washington, Seattle, WA, USA

Abstract

Objective—To determine the rate of preventable trauma deaths in an African hospital; identify the potential effect of improvements in trauma care over the past decade; and identify deficiencies in care that still need to be addressed.

Methods—A multidisciplinary panel assessed pre-hospital, hospital, and postmortem data on 89 consecutive in-hospital trauma deaths over 5-months in 2017 at the Komfo Anokye Teaching Hospital. The panel judged the preventability of each death. For definitely and potentially preventable deaths, the panel identified deficiencies in care.

Results—Thirteen percent (13%) of trauma deaths were definitely preventable, 47% potentially preventable, and 39% non-preventable. In comparison to a panel review in 2007, there was no change in total preventable deaths, but there had been a modest decrease in definitely preventable deaths (25% in 2007 to 13% in 2017, $p=0.07$) There was a notable change in the pattern of deficiency ($p=0.001$) with decreases in pre-hospital delay (19% of all trauma deaths in 2007 to 3%

Terms of use and reuse: academic research for non-commercial purposes, see here for full terms. <https://www.springer.com/aam-terms-v1>

For correspondence: Charles Mock, MD, Box 359960, Harborview Medical Center, 325 Ninth Avenue, Seattle, WA 98104, USA. Phone: +1-206-744-9430, cmock@uw.edu.

Publisher's Disclaimer: This Author Accepted Manuscript is a PDF file of an unedited peer-reviewed manuscript that has been accepted for publication but has not been copyedited or corrected. The official version of record that is published in the journal is kept up to date and so may therefore differ from this version.

Conflicts of interest: None declared by any of the authors

Approved by the Committee for Human Research and Publication Ethics, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

in 2017) and inadequate resuscitation (17% to 8%), but an increase in delay in treatment at the hospital (23% to 40%).

Conclusions—Over the past decade, there have been improvements in pre-hospital transport and in-hospital resuscitation. However, the preventable death rate remains unacceptably high and there are still deficiencies to address. This study also demonstrates that preventable death panel reviews are a feasible method of trauma quality improvement in the low- and middle-income country setting.

Keywords

Injury; trauma; low- and middle-income country; quality improvement

Introduction

Injury is a leading cause of death globally, with rates higher in low- and middle-income countries (LMICs, 69 deaths / 100,000 / year) than in high-income countries (49 deaths / 100,000 / year) [1]. Improvements in trauma care can lower this burden. Although some components of trauma care are expensive, many components are not. Improvements in the organization and planning for trauma care can be especially low-cost, yet very effective [2].

In many high-income countries better organized “trauma systems” have decreased mortality among all treated trauma patients by 15–20% and medically-preventable deaths by over 50% [3–6]. Such trauma systems entail several elements, including trauma center verification, pre-hospital triage criteria, and streamlining referrals through transfer agreements[7]. Another key component is quality improvement (QI) programs. One widely used trauma QI technique is preventable death panel review. In this, trauma deaths at a hospital or in an area are reviewed for the care provided. Panel participants decide whether deaths should be considered preventable or non-preventable. For preventable deaths, the panel decides which elements of care were deficient and recommends corrective action to prevent such occurrences in the future [8]. Such reviews can serve as catalysts to improve deficiencies and to monitor changes over time [9–11].

The techniques of preventable death panel reviews are embedded in routine hospital morbidity and mortality conferences in many high-income country hospitals [7, 8]. Area-wide panel reviews played an important role in trauma system development in the United States in the 1970s-1980s [5, 9, 11, 12]. Trauma QI in general and preventable death panel reviews in particular have been at low levels of development in LMICs, but are gradually increasing. Reports from Iran, Nigeria, and Pakistan have shown the utility of such panels to identify problems that can be affordably addressed [13–15].

A series of preventable death panel reviews were conducted in 2007 at the Komfo Anokye Teaching Hospital (KATH) in Kumasi, Ghana. These showed that 25% of in-hospital trauma deaths were definitely preventable and that leading deficiencies were pre-hospital delays and treatment delays at the hospital [16]. Other studies at KATH at the time corroborated these findings, showing delays in emergency surgery and low utilization of fluid resuscitation for patients in shock [17].

In the ensuing decade, there have been several improvements in trauma care at KATH, including creation of an emergency medicine residency and establishment of a dedicated accident and emergency center. We sought to re-evaluate the preventable death rate to see if it had changed since 2007 and whether the pattern of deficiencies had changed.

Methods

Setting

KATH has 1,500 beds and is the main referral hospital for the middle third of Ghana. Since 2007, there have been several changes in trauma care in Kumasi and KATH. The Ghana National Ambulance has increased in coverage, but most severely ill or injured persons are still brought to the hospital by relatives or good Samaritans using public and private transportation [18]. Even for these non-ambulance transports, increased use of cellphones has improved timeliness of arrival.

At KATH, a dedicated accident and emergency center was created in 2009. This replaced the prior less organized and minimally equipped casualty ward. KATH has been the site of the first emergency medicine residency in West Africa and the emergency department (ED) within the accident and emergency center is now staffed 24 hours per day with fully-trained emergency medicine physicians, whereas in 2007 there had been none. There has also been an increase in the number of fully-trained general surgeons from 6 (2007) to 9 (2017), neurosurgeons (from 1 to 4), and orthopaedic surgeons (from 2 to 8).

Process of care has also improved. Formal triage is done using the South African Triage Scale. Many people with respiratory distress undergo endotracheal intubation in the ED, which was rarely able to be done in 2007. The availability of radiologic services (including computerized tomography) has increased, but is still often limited by need for cash payment in advance of service.

Data gathering

All injury-related deaths recorded at the KATH mortuary during January-May, 2017, were studied. For persons who died after arrival at the hospital, autopsy reports and medical records were abstracted by research assistants. A paragraph summary was prepared on each case and reviewed by the site supervisor (DKY) for completeness. Data were gathered on blunt and penetrating trauma. Deaths due to burns, suffocation, drowning, and poisoning were excluded.

Preventable death panel reviews

Methods for trauma preventable death panel reviews recommended by the World Health Organization (WHO) were used [8]. A panel of seven experts in trauma care at KATH was constituted and included one of each of: general surgeon, orthopaedic surgeon, senior ED nurse, emergency physician, neurosurgeon, pathologist, and others as needed. All had sound knowledge of the resources and standards for trauma care at KATH.

Anonymous abstracts of each case were provided to members of the panel in advance of the meetings. Each member reviewed 10–20 case summaries and made preliminary assessment

of preventability. Cases were then reviewed by the full panel who voted as to whether the death was: definitely preventable, potentially preventable, or non-preventable, as per WHO definitions [8]. Assignment of preventability was based on trauma care capabilities available at KATH.

For each case judged as definitely preventable or potentially preventable, one main deficiency in care was assigned and categorized as to type: failure of airway management, hemorrhage, inadequate fluid resuscitation, treatment delay, or other. Location of deficiencies was categorized as: pre-hospital, ED, operating room, intensive care unit, or ward [8, 11]. Corrective actions to prevent similar future occurrences were recommended.

Chi square was used to compare the findings from 2007 vs. 2017. The 2007 data included both patients brought in dead and those who arrived alive; but the 2017 data included only those who arrived alive. Hence, for the comparison, only patients who arrived alive were included. To ensure comparability, the panel reviews were conducted in an identical manner both times, with representation of the same disciplines [16]. For each set of panels, there were initial organizational meetings at which the panel members were oriented to the WHO methodology and definitions of preventability.

The study was approved by the Kwame Nkrumah University of Science and Technology IRB.

Results

Over the 5-month study period, 147 trauma deaths were recorded at KATH. Of these, 58 deaths occurred in the pre-hospital setting and were excluded. Eighty-nine (89) in-hospital deaths formed the basis of the study. They were primarily young adult males who had been in motor vehicular crashes (Table 1). Autopsies had been performed in 72 of these cases.

Of the 89 trauma deaths reviewed, 12 (13%) were judged definitely preventable, 42 (47%) potentially preventable, and 35 (39%) non-preventable. There were notable differences among these categories as to cause of death and arrival Glasgow Coma Scale (GCS) (Table 2). Most people with definitely preventable deaths died from hemorrhage and all had GCS above 8, while those with potentially preventable deaths were more likely to have had a serious head injury. There were no significant differences between the groups for location of death, time of death, or pre-hospital time. Cause of death was primarily hemorrhage for definitely preventable cases and central nervous system for potentially preventable cases.

There were 54 deficiencies in care identified (Table 3). The most common deficiency was treatment delay. The two categories of preventable deaths both had treatment delay as their leading deficiency, but differed in the next most common deficiencies. The most common location of deficiency overall was the ED. This was the main site of deficiency for potentially preventable cases, whereas the locations of deficiency for definitely preventable cases were fairly evenly distributed. Of the 22 cases of delayed treatment, most were delays in surgery: burr hole or craniotomy (8), operative C-spine stabilization (4), surgery to control extremity bleeding (5), and laparotomy (2).

The panel recommended several corrective actions to address the above deficiencies (Table 4). These covered aspects of training, staffing, protocols, and financing in several departments.

Compared to 2007, there was no change in the percentage of preventable vs. non-preventable deaths (Table 5). However, among the preventable deaths, there was a shift towards less definitely preventable deaths and more potentially preventable deaths. There was no change in cause of death. There was a marked change in types of deficiencies, with reductions in pre-hospital delays and inadequate fluid resuscitation, but with an increase in treatment delay at the hospital.

Discussion

This study sought to determine the proportion of preventable trauma deaths at an African hospital, identify the potential effect of improvements in care over the past decade, and identify opportunities for future improvements. Compared to a similar study done 10 years previously [16] there was no change in the percentage of preventable vs. non-preventable deaths. However, among the preventable deaths, there was a shift towards less definitely preventable deaths and more potentially preventable deaths. There was a notable change in the pattern of deficiency with decreases in pre-hospital delay and inadequate resuscitation, but increases in treatment delays at the hospital. These findings are corroborated by a smaller, interim preventable death study at KATH which found a similar percentage of definitely preventable trauma death rate (11%) to the current study [19].

The current study demonstrates the feasibility and utility of preventable death panel review as a method for trauma QI in LMICs. Such panels have been used in high-income countries for several decades to identify problems, stimulate corrective action, and monitor changes over time. A number of high-income countries including Germany, Italy, Netherlands, South Korea, United Kingdom, and United States have widely used panel reviews, with percentages of definitely preventable deaths ranging from 2–11% [11, 20–23]. There is a small, but growing literature on panel reviews in LMICs, with reports from Iran, Nigeria, and Pakistan, with definitely preventable deaths ranging from 22–33% [13–15]. A study in India showed preventability varied with injury severity. Overall preventability was 58%, but higher (71%) in mildly injured patients who died (injury severity score {ISS} of 1–9) and lower (44%) in profoundly injured (ISS>25) injured patients [24].

In many high-income countries, additional, more complex methods of trauma QI are used, such as trauma registries and audit filters, which provide additional capabilities [7, 8]. Nonetheless, several researchers have shown that panel reviews offer benefits, identifying additional correctable problems beyond those found by statistical methods. Hence, the various techniques of trauma QI should be viewed as complimentary [25, 26].

The current study also documented changes in pattern of deficiencies, with a marked reduction in pre-hospital delays. This is notable as the Ghana National Ambulance Service still covers a minority of cases, with most emergency cases still transported by private vehicle or taxi [18]. It is the impression of the authors that the decrease in pre-hospital delays

was likely due to: better communication (especially cellphones) to call friends and relatives for help after motor vehicle crashes and other injuries; and a more organized trauma system, with smaller hospitals in better communication with tertiary centers to determine which cases to prioritize for transfer.

In hospital, the percentage of patients with deficiencies in fluid resuscitation decreased. This is likely due to the emphasis that had been placed on better organized trauma care in general and on fluid resuscitation in particular, in part related to dissemination of the 2007 study findings at KATH. In the opposite direction, there was an increase in treatment delays. The reason for this is not obvious, as there are now more emergency physicians and surgical specialists. Possibly the decrease in pre-hospital delays has led to more unstable patients arriving alive, thus necessitating more critical decisions and more possibility for error. Also, in 2007 the possibility for emergency endotracheal intubation in the ED was almost non-existent and airway issues were not listed separately in the panel review, but bundled within the broader category of treatment delays. It is possible that there was greater detection of airway problems in 2017.

Problems identified by panel reviews and other trauma QI activities are often amenable to low-cost and feasible corrective action, such as improving training and supplies for initial management, as well as better organization and planning for trauma care system-wide. The small literature on trauma QI in LMICs has documented a few success stories in which QI activities have stimulated improvements[8]. For example, in Thailand, implementation of a trauma registry and its use for trauma QI at a major trauma center steadily decreased overall trauma mortality from 8% to 4.6% over a 6 year period [27].

The current study is one of the first to report improvements in care documented by and, in part, stimulated by preventable death panel reviews in an LMIC. Documentation of changes in trauma care over time is especially uncommon, thus far, in Africa. Changes in this study include a considerable in prehospital delay as a cause of preventable deaths, despite the fact that most people continue to be brought in by taxis and private vehicles, not ambulances. Also, at least partly related to the prior panel, there has been a marked decrease in inadequate resuscitation as a cause of preventable deaths.

The use of preventable death panels is eminently generalizable given their low-cost and feasibility. Open peer review might be less feasible in some countries, due to reluctance to challenge authority or to a sense that critiquing care by others might be construed as blaming. However, these were not problems in this study.

Before concluding, the study limitations should be addressed. First, panel reviews are subjective as regards determination of preventability. Care should be exercised in comparing studies done in different locations or different times, due to the possibility of bias. Additions of objective methods such as ISS would help to eliminate some of this bias. Second, classification methods differed slightly between the two time periods in this study, with airway problems categorized as a specific problem in 2017, but not in 2007. Third, the sample size is small, so statistical testing should be regarded as more exploratory than confirmatory. Fourth, capabilities at KATH changed over the study period and the definition

of preventability was based on capabilities available at the time. Hence, the findings from 2017 were based on a higher standard of care, which may have increased the preventable death rate compared to 2007, somewhat obscuring the decrease in definitely preventable deaths that was observed. Nonetheless, this study has the strength of methodologically rigorous reviews, conducted in the same way at both times, using WHO guidelines.

Conclusion

This preventable death panel review demonstrated a notable change in the pattern of deficiencies of care, with decreases in pre-hospital delays and inadequate resuscitation, in response to improvements in care over the past 10 years. However, the overall preventable death rate remains unacceptably high and there are still a number of deficiencies to be addressed. Most of the corrective action recommended by the panel should be feasible to implement. This study has also demonstrated that preventable death panel reviews are a feasible and effective method of trauma QI in LMICs that can both identify problems and stimulate corrective action.

Acknowledgement

This study was funded by grant D43-TW007267 from the Fogarty International Center of the US National Institutes of Health. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

REFERENCES

1. World Health Organization. Global Health Estimates. https://www.who.int/healthinfo/global_burden_disease/estimates/en/. Accessed May 21, 2020.
2. World Health Organization. Guidelines for Essential Trauma Care. Geneva, World Health Organization, 2004.
3. Nathens AB, Jurkovich GJ, Cummings P, et al. (2000) The effect of organized systems of trauma care on motor vehicle crash mortality. JAMA 283:1990–1994 [PubMed: 10789667]
4. Nathens AB, Jurkovich GJ, Rivara FP, et al. (2000) Effectiveness of state trauma systems in reducing injury-related mortality: a national evaluation. J Trauma 48:25–30; discussion 30–21 [PubMed: 10647561]
5. Mann NC, Mullins RJ, MacKenzie EJ, et al. (1999) Systematic review of published evidence regarding trauma system effectiveness. J Trauma 47:S25–33 [PubMed: 10496607]
6. Jurkovich GJ, Mock C (1999) Systematic review of trauma system effectiveness based on registry comparisons. J Trauma 47:S46–55 [PubMed: 10496611]
7. American College of Surgeons. CoT, Resources for Optimal Care of the Injured 2014 (2014) American College of Surgeons, Chicago, Ill., p. vii, 181 pages
8. World Health Organization. Guidelines for Trauma Quality Improvement Programmes, Geneva, World Health Organization, 2009.
9. West JG, Trunkey DD, Lim RC (1979) Systems of trauma care. A study of two counties. Arch Surg 114:455–460 [PubMed: 435058]
10. West JG (1981) An autopsy method for evaluating trauma care. J Trauma 21:32–34 [PubMed: 7463535]
11. Esposito TJ, Sanddal TL, Reynolds SA, et al. (2003) Effect of a voluntary trauma system on preventable death and inappropriate care in a rural state. J Trauma 54:663–669; discussion 669–670 [PubMed: 12707527]
12. Cales RH (1984) Trauma mortality in Orange County: the effect of implementation of a regional trauma system. Ann Emerg Med 13:1–10 [PubMed: 6689851]

13. Zafarghandi MR, Modagheh MH, Roudsari BS (2003) Preventable trauma death in Tehran: an estimate of trauma care quality in teaching hospitals. *J Trauma* 55:459–465 [PubMed: 14501887]
14. Jat AA, Khan MR, Zafar H, et al. (2004) Peer review audit of trauma deaths in a developing country. *Asian J Surg* 27:58–64 [PubMed: 14719518]
15. Afuwape OO, Okolo CA, Akinyemi OA (2011) Preventable trauma deaths in Ibadan: a comparison of revised trauma score and panel review. *West Afr J Med* 30:19–23 [PubMed: 21863584]
16. Yeboah D, Mock C, Karikari P, et al. (2014) Minimizing preventable trauma deaths in a limited-resource setting: a test-case of a multidisciplinary panel review approach at the Komfo Anokye Teaching Hospital in Ghana. *World J Surg* 38:1707–1712 [PubMed: 24449414]
17. London JA, Mock CN, Quansah RE, et al. (2001) Priorities for improving hospital-based trauma care in an African city. *J Trauma* 51:747–753 [PubMed: 11586170]
18. Zakariah A, Stewart BT, Boateng E, et al. (2017) The Birth and Growth of the National Ambulance Service in Ghana. *Prehosp Disaster Med* 32:83–93 [PubMed: 27938469]
19. Oteng RA, Osei-Kwame D, Forson-Adae MSE, et al. (2019) The preventability of trauma-related death at a tertiary hospital in Ghana: a multidisciplinary panel review approach. *African Journal of Emergency Medicine* 9:202–206 [PubMed: 31890485]
20. Maio RF, Burney RE, Gregor MA, et al. (1996) A study of preventable trauma mortality in rural Michigan. *J Trauma* 41:83–90 [PubMed: 8676428]
21. MacKenzie EJ (1999) Review of evidence regarding trauma system effectiveness resulting from panel studies. *J Trauma* 47:S34–41 [PubMed: 10496608]
22. Pfeifer R, Halvachizadeh S, Schick S, et al. (2019) Are Pre-hospital Trauma Deaths Preventable? A Systematic Literature Review. *World J Surg* 43:2438–2446 [PubMed: 31214829]
23. Jung K, Kim I, Park SK, et al. (2019) Preventable Trauma Death Rate after Establishing a National Trauma System in Korea. *J Korean Med Sci* 34:e65 [PubMed: 30833882]
24. Roy N, Kizhakke Veetil D, Khajanchi MU, et al. (2017) Learning from 2523 trauma deaths in India- opportunities to prevent in-hospital deaths. *BMC Health Serv Res* 17:142 [PubMed: 28209192]
25. Heim C, Cole E, West A, et al. (2016) Survival prediction algorithms miss significant opportunities for improvement if used for case selection in trauma quality improvement programs. *Injury* 47:1960–1965 [PubMed: 27343135]
26. Kwon AM, Garbett NC, Kloecker GH (2014) Pooled preventable death rates in trauma patients : Meta analysis and systematic review since 1990. *Eur J Trauma Emerg Surg* 40:279–285 [PubMed: 26816061]
27. World Health Organization. Strengthening Care for the Injured: Success Stories and Lessons Learned from Around the World, Geneva, WHO, 2010.

Table 1.

Distribution of 89 trauma deaths by gender, age, mechanism of injury, pre-hospital delays, arrival GCS score, location of death and time of death.

Variable	Category	Frequency (N=89)	Percentage (%)
Gender	Female	21	24
	Male	68	76
Age (years)	0–5	3	3
	6–18	14	16
	19–49	51	57
	>49	21	24
Site of injury	Home	8	9
	Road	74	83
	Workplace	7	8
Mechanism of injury	Motor vehicle crash	70	79
	Pedestrian	3	3
	Fall	12	13
	Assault	2	2
	Gunshot	1	1
	Miscellaneous	1	1
Pre-hospital delay (hours)	6	40	45
	>6	49	55
GCS	8	44	49
	>8	45	51
Location of death	Emergency department	72	81
	Ward	17	19
Time of death	<24 h	44	49
	24–<72 h	11	12
	3–7 days	26	29
	>7 days	8	9
Cause of death	Airway	3	3
	CNS	64	72
	Hemorrhage	21	24
	Sepsis	1	1

CNS: central nervous system. GCS: Glasgow Coma Scale

Percentages might not total to 100% due to rounding

Table 2.

Associations between cause of death, GCS, time of death, location of death, and death preventability.

Variable Category	Death Preventability			p-value
	Definitely preventable N (%)	Potentially preventable N (%)	Non-preventable N (%)	
Cause of death				<0.0001
- Airway	1 (8)	0 (0)	2 (6)	
- CNS	1 (8)	33 (79)	30 (86)	
- Hemorrhage	9 (75)	9 (21)	3 (9)	
- Sepsis	1 (8)	0 (0)	0 (0)	
GCS				<0.0001
- 8	0 (0)	19 (45)	25 (71)	
- >8	12 (100)	23 (55)	10 (29)	
Location of death				0.126
- Emergency department	9 (75)	31 (74)	32 (91)	
- Ward	3 (25)	11 (26)	3 (9)	
Time of death				0.669
- <24 h	8 (67)	17 (40)	19 (54)	
- 24-<72h	1 (8)	5 (12)	5 (14)	
- 3-7 days	2 (17)	15 (36)	9 (26)	
- >7 days	1 (8)	5 (12)	2 (6)	
Pre-hospital time				0.233
- 6	7 (58)	15 (36)	18 (51)	
- >6	5 (42)	27 (64)	17 (49)	

Percentages might not total to 100% due to rounding. CNS: central nervous system.

Table 3.

Fifty-four cases of care deficiencies documented in 89 trauma deaths

Variable	Total N (%)	Definitely Preventable N (%)	Potentially Preventable N (%)	p-value
Type of deficiency				
Pre-hospital delay	3 (6)	3 (25)	0 (0)	0.0008
Delay in diagnosis	8 (15)	0 (0)	8 (19)	
Delay in initiating treatment	22 (41)	6 (50)	16 (38)	
Inadequate fluid resuscitation	7 (13)	3 (25)	4 (10)	
Failure of airway management	14 (26)	0 (0)	14 (33)	
Location of deficiency				
Pre-hospital delay	5 (9)	3 (25)	2 (5)	<0.0001
Emergency department	44 (81)	5 (42)	39 (93)	
Operating theater	4 (7)	4 (33)	0 (0)	
Intensive care unit	1 (2)	0 (0.00)	1 (2)	

Percentages might not total to 100% due to rounding.

Table 4.

Corrective actions recommended by the panel

Category	Action
Emergency Department (ED)	Increased use of continuing education courses (such as ATLS) for doctors and nurses working in ED. These courses should be free for all ED staff.
	Increased emphasis on systematic assessment of multiply injured patients.
	Protocol to perform endotracheal intubation and mechanical ventilation in ED for all patients with GCS 8 or less.
	Protocol to have a cervical collar applied initially until cervical spine is cleared. Increase cervical collar availability in ED.
Surgery	Stand-by surgical team available 24 hours per day with capacity to perform emergency laparotomy and craniotomy.
	Operating theatre space near ED that is dedicated solely for emergency procedures. This theatre should have 24 hour standby availability of nurses and anesthesia.
Radiology	Cost of initial head CT waived as need for payment on site in advance of the scan was a major barrier to accessibility.
Trauma system	Public information through community health workers on need to come for care early on for severe injury.
	Training for workers at lower level health facilities (primary health care clinics and small hospitals) to refer high-energy trauma patients promptly.

ATLS: Advanced Trauma Life Support. GCS: Glasgow Coma Scale. CT: Computerized tomography.

Table 5.

Change in deficiencies in care, cause of death, and preventability between 2007 and 2017.

Category	2007 (N %) N=64	2017 (N %) N=89	Significance
Type of deficiency *			p=0.001
- Pre-hospital delay	12 (19%)	3 (3%)	
- Delay in diagnosis	1 (2%)	8 (9%)	
- Delay in treatment	15 (23%)	36 (40%) **	
- Inadequate fluid resuscitation	11 (17%)	7 (8%)	
No deficiency	25 (39%)	35 (39%)	
Cause of death			p=0.36***
- Airway	2 (3%)	3 (3%)	
- CNS	42 (66%)	64 (72%)	
- Hemorrhage	14 (22%)	21 (24%)	
- Sepsis	4 (6%)	1 (1%)	
- Indeterminate	2 (3%)		
Preventability			p=0.15
- Definitely preventable	16 (25%)	12 (13%)	
- Potentially preventable	23 (36%)	42 (47%)	
- Non-preventable	25 (39%)	35 (39%)	
Preventability			p=0.07
- Definitely preventable	16 (25%)	12 (13%)	
- Potentially preventable and non-preventable	48 (75%)	77 (86%)	
Preventable deaths	N=39	N=54	
Preventability			p=0.05
- Definitely preventable	16 (41%)	12 (22%)	
- Potentially preventable	23 (59%)	42 (78%)	

* One most significant deficiency assigned to preventable and potentially preventable deaths.

** Includes 15 cases of inadequate airway control in 2017 (which was not separately listed in 2007).

*** Based on those with assigned cause of death (excluding indeterminate causes).

Data from 2007 includes only in-hospital deaths, excluding pre-hospital deaths that had been included in the original publication[16].

Percentages might not total to 100% due to rounding. CNS: central nervous system.