

Stop the Bleed: gap analysis and geographical evaluation of incident locations

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ABSTRACT

Background Trauma is a major public health issue. In 2015, the White House launched the “Stop the Bleed” (STB) campaign, which aims to equip would-be bystanders with the ability and equipment to assist in bleeding emergencies. This study sought to estimate the number of patients who might benefit from STB intervention, in an everyday setting, and their spatial injury profile.

Methods This is a retrospective analysis of trauma registry and medical examiners’ data, collected between 2013 and 2017. The majority of patients were male. The median age was 32 years. Incidents were geocoded by ZIP code, and mapped using Quantum Geographic Information System (QGIS).

Results We identified 139 patients from medical examiner records and UAB’s trauma registry who might have benefitted from STB intervention. The number of incidents per year ranged from 22 to 35, averaging 2.3 incidents per month. There was no evidence of geographical clustering, although the small number of incidents precluded a formal geostatistical analysis.

Conclusion The number of patients who might benefit from STB interventions on a daily basis is small, and incident locations are difficult to predict. Educating the public in how to stop bleeding is appealing, but providing easy and widespread access to STB kits may be difficult. Although there are parallels to the provision of cardiopulmonary resuscitation and defibrillation for cardiac arrest, there are also differences, which should not be overlooked.

BACKGROUND

Trauma is a major public health issue. Worldwide, approximately 5.8 million deaths result from trauma every year, and trauma is the leading cause of death in individuals aged 1 to 46 years.¹ Bleeding is responsible for approximately one-third of trauma deaths, around one-fifth of which are thought to be preventable.^{2–4} The natural history of uncontrolled hemorrhage is cardiovascular collapse with consequent cerebral and myocardial hypoperfusion, ultimately leading to death.⁵ When hemorrhage is controlled expeditiously, patients often recover.⁶

Torso hemorrhage requires operative treatment or advanced interventions to control bleeding, but hemorrhage from the extremities can usually be controlled with relatively simple means, such as direct pressure, or the application of a tourniquet.

The “Stop the Bleed” (STB) initiative aims to train, equip, and empower those without medical training to assist in a bleeding emergency, through a combination of education and better access to equipment such as tourniquets and hemostatic dressings.⁷ The initiative has been likened to the widespread provision of automated external defibrillators (AED), to facilitate early defibrillation in patients with cardiac arrest due to ventricular fibrillation. The increasing frequency of mass casualty events, particularly those involving ballistic injuries, has heightened awareness of the problem of the importance of early hemorrhage control in the United States.⁸

Since the programme’s inception, many community members have been trained in basic hemorrhage control techniques, and STB kits have been distributed to schools, churches, airports, malls, and many other locations.⁹ However, the kits are costly – prices range from \$69 to \$950 per unit¹⁰ – and many more kits will be required before accessibility will reach levels comparable to those of AED.

A more targeted approach to the selection of locations where the kits are most likely to be needed would be helpful. However, it is not known how many patients might benefit from STB interventions, and whether these incidents show evidence of geographical clustering. Given that sociological and environmental factors influences trauma occurrences,^{11 12} we hypothesized that geographical distribution of the resulting injuries might also occur in identifiable “hot spots”.

The aim of this project was to conduct a geostatistical analysis of the number of injuries that might benefit from STB intervention, and their spatial injury profile, using a single county in the State of Alabama as a case study.

METHODS

We performed a retrospective analysis of trauma registry data from the level I trauma center at the University of Alabama at Birmingham (UAB) Hospital, and medical examiners’ data from Jefferson County, Alabama. Jefferson County is the most populous county in the State of Alabama, with a population of approximately 660 000. UAB Hospital is the only level I trauma center in the region. We examined trauma incidents that occurred between 2013 and 2017. The study was approved by the Institutional Review Board.

Table 1 Trauma registry case definitions

Injuries likely amenable to STB intervention, and would most likely need a tourniquet or advanced hemostatic dressing		Injuries likely amenable to STB intervention, but would probably not benefit from tourniquet (needs dressing/direct pressure only)	
AIS Code	Description	AIS Code	Description
Lower Extremity			
800 999.9	Died of lower extremity injury without further substantiation of injuries or no autopsy confirmation of specific injuries	813 002.4	Crush injury, at or above knee, below hip
811 000.3	Amputation (traumatic), partial or complete between hip and foot, but NFS as to specific anatomic sites	813 003.3	Crush injury, below knee, at or above ankle
811 002.4	Amputation (traumatic), at or above knee, below hip	814 002.3	Degloving injury, entire extremity
811 012.5	Amputation (traumatic), bilateral	814 004.2	Degloving injury, thigh or calf
811 003.3	Amputation (traumatic), below knee, at or above ankle	816 006.3	Penetrating injury NFS, with blood loss >20% by volume
820 208.4	Femoral artery, major; rupture; transection; segmental loss; blood loss >20% by volume	816 017.3	Penetrating injury at or above knee, with blood loss >20% by volume
820 608.3	Popliteal artery, major; rupture; transection; segmental loss; blood loss >20% by volume	810 606.3	Skin/subcutaneous/muscle NFS, blood loss >20% by volume
821 008.3	Other named arteries NFS (e.g., tibial, peroneal), major; rupture; transection; segmental loss; blood loss >20% by volume	820 406.3	Femoral vein NFS, major; rupture; transection; segmental loss; blood loss >20% by volume
		820 806.3	Popliteal vein NFS, major; rupture; transection; segmental loss; blood loss >20% by volume
Upper Extremity			
700 999.9	Died of upper extremity injury without further substantiation of injuries or no autopsy confirmation of specific injuries	713 002.4	Crush injury, at or above elbow, below shoulder
711 000.3	Amputation (traumatic), partial or complete between shoulder and hand, but NFS as to specific anatomic sites	713 003.3	Crush injury, below elbow, at or above wrist
711 002.4	Amputation (traumatic), at or above elbow, below shoulder	714 001.3	Degloving injury, entire extremity
711 012.5	Amputation (traumatic), bilateral	714 002.2	Degloving injury, arm or forearm, including elbow
711 003.3	Amputation (traumatic), below elbow, at or above wrist	716 006.3	Penetrating injury NFS, with blood loss >20% by volume
720 608.3	Brachial artery, major; rupture; transection; segmental loss; blood loss >20% by volume	716 017.3	Penetrating injury at or above shoulder, with blood loss >20% by volume
721 008.3	Other named arteries NFS (e.g., radial, ulnar), major; rupture; transection; segmental loss; blood loss >20% by volume	710 606.3	Skin/subcutaneous/muscle NFS, blood loss >20% by volume
		720 406.3	Axillary vein NFS, major; rupture; transection; segmental loss; blood loss >20% by volume
		720 806.3	Brachial vein NFS, major; rupture; transection; segmental loss; blood loss >20% by volume

STB, Stop the Bleed.

Case definition

We used abbreviated injury scale (AIS) codes to search the trauma registry for patients with injuries that might have been amenable to STB intervention such as tourniquet or advanced hemostatic dressing application (traumatic amputations major arterial injuries associated with marked blood loss) or direct pressure and simple dressings (crush and degloving injuries, venous injuries associated with marked blood loss). These injuries were mapped to AIS codes (table 1). Medical examiner's data, which are not AIS-coded, were reviewed manually to identify pre-hospital fatalities with extremity injuries that might have survived if STB interventions had been utilized.

Analysis

We extracted demographic, location, injury mechanism, injury severity, and outcome data for all patients. The data were

summarized using descriptive statistics. Where the precise incident was not available, we used the place of residence, as most injuries occur at or close to home.^{13 14} Incidents were geocoded by ZIP code, and analyzed using QGIS, an open-source geographical information systems software package. Patients injured outside of Jefferson County were excluded to ensure congruity between trauma center and medical examiner's data. The results are displayed as maps, showing both the crude number of incidents per ZIP code tabulation area (ZCTA), and the number of incidents per population per ZCTA.

RESULTS

During the 5 year period, there were a total of 139 patients who might have benefitted from STB interventions. Among all patients identified, 131 (94%) were admitted to UAB's Trauma Center. The remaining 8 (6%) individuals died without having

Table 2 Characteristics of study population (n=139)

Source	
Trauma registry, n (%)	131 (94%)
Medical examiner, n (%)	8 (6%)
Year injured	
2013, n (%)	27 (19%)
2014, n (%)	27 (19%)
2015, n (%)	22 (16%)
2016, n (%)	28 (20%)
2017, n (%)	35 (25%)
Demographics	
Age, years, median (IQR)	32 (25–50)
Male gender, n (%)	118 (85%)
Mechanism	
Penetrating/ballistic, n (%)	54 (39%)
Penetrating/non-ballistic, n (%)	11 (8%)
Blunt, n (%)	74 (53%)
Injury sites	
Upper extremity, n (%)	54 (39%)
Lower extremity, n (%)	85 (61%)
Injury types	
Likely need for tourniquet or advanced hemostatics, n (%)	77 (55%)
Probably no need for tourniquet or advanced hemostatics, n (%)	62 (45%)
Injury severity*	
Injury severity score, median (IQR)	14 (9.0–20.5)
Injury severity score >15, n (%)	67 (48%)
Outcome	
Prehospital death, n (%)	8 (6%)
In-hospital death, n (%)	18 (13%)
Survived, n (%)	113 (81%)

*trauma registry patients only.

contact with medical services. Additionally, 18 (14%) of the patients admitted to hospital died. The number of incidents per year ranged from 22 to 35, averaging 2.3 incidents per month.

The baseline characteristics of the study group are shown in **table 2**. The majority of the patients (85%) were male and the median age was 32 years (IQR 25 to 50). A median injury severity score of 14 (IQR 9.0 to 20.5) was observed, whereas a total of 67 (48%) injuries had an injury severity score >15. Most patients (53%) sustained blunt trauma, whereas 65 (47%) sustained penetrating injuries. Of the 65 penetrating injuries, 54 (83%) were ballistic (gunshot) injuries, whereas 11 (17%) patients were non-ballistic.

All injuries were limited to the extremities, with 85 (61%) sustaining injuries to the lower extremities, and 54 (39%) to the upper extremities. Among all injuries, 77 (55%) involved arterial damage or traumatic amputation, which would most likely have required a tourniquet or advanced hemostatic to control hemorrhage. Conversely, 62 (45%) of the injuries were venous or degloving injuries, which could have been controlled by simpler means.

Figure 1 shows the geographical distribution of traumatic hemorrhage incidents. The crude number of incidents, denoted by blue circles, varied from 0 to 11 per ZCTA.

The number of incidents per population is shown by area color-coding, and ranged from 0 to 1.27 incidents per 1000 population (during the 5-year study period). The central areas

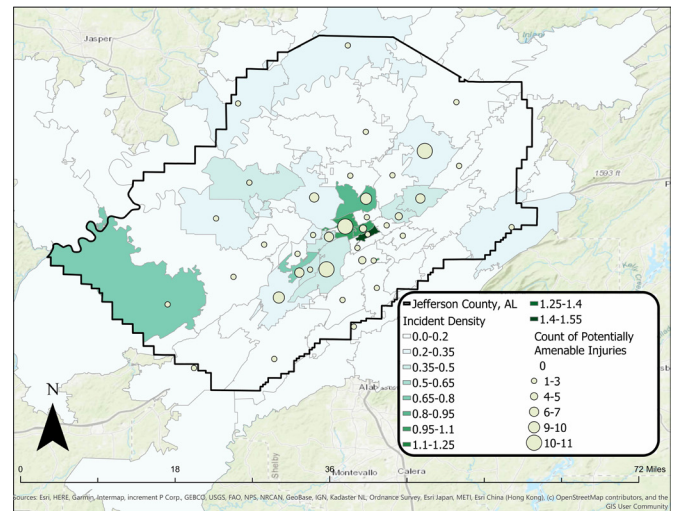


Figure 1 Map of Jefferson County, showing number of patients with injuries potentially amenable to “stop the bleed” intervention (yellow circles), as well as the number of such injuries per population (by ZIP code tabulation area, shaded). please note that the ZIP code tabulation areas and County boundary are not congruous.

of the county, corresponding to the central Birmingham, appear to have a higher incidence rate. However, the geographical distribution beyond this area is heterogeneous, with no identifiable geographical patterns or differences between ZCTAs. The number of incidents per areal unit were too small to conduct a formal statistical comparison.

DISCUSSION

This study was originally conceived as a “siting project”, to inform the placement of STB kits where they are most likely to be needed. However, our results demonstrate that the number of patients who suffer injuries that might benefit from STB interventions in Jefferson County is small; and that the geographical locations of these incidents are not easily predictable.

These findings raise important questions regarding the aims of the STB Programme. The initiative was launched in the aftermath of the Sandy Hook shootings, and similar mass casualty events.⁷ It attempts to transfer the lessons learnt during the wars in Afghanistan and Iraq, relating to early hemorrhage control and the use of tourniquets, to the civilian setting.⁸ The programme seeks to inform, educate, and empower would-be bystanders to serve as immediate responders to save lives by control of hemorrhage at the scene of injury.

These aims have invariably invited comparisons to cardiopulmonary resuscitation for (medical) cardiac arrests, and public access to AED. Although there are similarities, our findings highlight that there are also important differences. Publicly available data from the Alabama Department of Public Health, for a period of 21 months (January 2018 to September 2019) shows that there were 354 incidences where an AED had been applied, prior to the arrival of Emergency Medical Services, in Jefferson County. This equates to 16.8 AED uses per month, more than seven times the predicted rate of STB interventions identified in this study. (G. Varner, personal communication, October 23, 2019) Both public health campaigns can be regarded as consisting of a “skill” component (application of direct or indirect pressure for external hemorrhage, initiation of chest compressions for medical cardiac arrest) and an “equipment” component (provision of tourniquets and hemostatic

dressings for controlling hemorrhage, and provision of AED for cardioversion). Providing education in how to stop bleeding and perform chest compressions correctly is associated with few disadvantages. The provision of equipment, in contrast, is more complex, because it is associated with higher costs. These public health interventions should ideally be shown to be effective – as the provision of AED has.

The biggest difference between the two programme, as evidenced by their origins, however, lies in the fact that mass shooting events can result in unpredictable clusters of large numbers of patients requiring STB interventions – and large numbers of tourniquets and hemostatic dressings. There is no equivalent of medical cardiac arrests occurring *en masse*. Philosophically, the STB campaign needs to decide whether it aims to prepare high-risk locations such as schools, colleges, malls and places of worship with the skills and equipment to deal with a rare event, or whether it intends to improve the survival of patients injured in isolated, everyday incidents.

This was a retrospective study, conducted in a single county, and therefore has limitations. Injuries abstracted from a trauma registry or medical examiners' records may not accurately reflect what the public or emergency medical service providers would do when faced with external hemorrhage. There is also the possibility that we are not capturing all potential patients in the county. Some patients may not have sought medical attention and some may have been taken to other hospitals. However, UAB is the only level I trauma center in the region thus it is expected that most patients with difficult-to-control hemorrhage to be taken to our center.

CONCLUSION

In our setting, the number of patients who might benefit from STB interventions appears to be small, and their locations are not easily predicted. Consideration should be given as to whether STB is primarily intended to address the consequences of a mass casualty event, or whether it should be available to all.

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