Original Investigation | PACIFIC COAST SURGICAL ASSOCIATION

Trauma Surveillance in Cape Town, South Africa
An Analysis of 9236 Consecutive Trauma Center Admissions

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IMPORTANCE Trauma is a leading cause of death and disability worldwide. In many low- and middle-income countries, formal trauma surveillance strategies have not yet been widely implemented.

OBJECTIVE To formalize injury data collection at Groote Schuur Hospital, the chief academic hospital of the University of Cape Town, a level I trauma center, and one of the largest trauma referral hospitals in the world.

DESIGN, SETTING, AND PARTICIPANTS This was a prospective study of all trauma admissions from October 1, 2010, through September 30, 2011, at Groote Schuur Hospital. A standard admission form was developed with multidisciplinary input and was used for both clinical and data abstraction purposes. Analysis of data was performed in 3 parts: demographics of injury, injury risk by location, and access to and maturity of trauma services. Geographic information science was then used to create satellite imaging of injury "hot spots" and to track referral patterns. Finally, the World Health Organization trauma system maturity index was used to evaluate the current breadth of the trauma system in place.

MAIN OUTCOMES AND MEASURES The demographics of trauma patients, the distribution of injury in a large metropolitan catchment, and the patterns of injury referral and patient movement within the trauma system.

RESULTS The minimum 34-point data set captured relevant demographic, geographic, incident, and clinical data for 9236 patients. Data field completion rates were highly variable. An analysis of demographics of injury (age, sex, and mechanism of injury) was performed. Most violence occurred toward males (71.3%) who were younger than 40 years of age (74.6%). We demonstrated high rates of violent interpersonal injury (71.6% of intentional injury) and motor vehicle injury (18.8% of all injuries). There was a strong association between injury and alcohol use, with alcohol implicated in at least 30.1% of trauma admissions. From a systems standpoint, the data suggest a mature pattern of referral consistent with the presence of an inclusive trauma system.

CONCLUSIONS AND RELEVANCE The implementation of injury surveillance at Groote Schuur Hospital improved insights about injury risk based on demographics and neighborhood as well as access to service based on patterns of referral. This information will guide further development of South Africa's already advanced trauma system.

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Trauma is a leading cause of death and disability worldwide, contributing significantly to the global burden of disease. The World Health Organization (WHO) estimates that injury is responsible for more than 5 million deaths annually, more than the mortality caused by human immunodeficiency virus, malaria, and tuberculosis combined.[1] More than 90% of injury occurs in low- and middle-income countries, where formal trauma systems and methods for data tracking have not yet been widely implemented.[2,3]

The burden of injury is significant in South Africa.[4] Projects such as the National Injury Mortality Surveillance System have used mortuary-based data to capture injury-related deaths based on Global Burden of Disease injury classifications.[5] For 2007, that system recorded 33 484 injury-related deaths, more than one-third of which were due to violence (11 983, [35.8%]), followed by traffic injuries (10 780 [32.0%]), other injuries (4366 [13%.0]), suicide (3422 [10.2%]), and undetermined causes (2933 [8.8%]). Although trending downward, the murder rate in South Africa is still 30.9 per 100 000 population, 4.5 times the global average.[6] The escalating rate of traffic-related deaths, 33.2 per 100 000 in 2011, suggests the need for proportionate research efforts surrounding prevention and education.[7] More than half of pedestrian deaths occur when drivers are under the influence of alcohol.[8]

Injury data have historically been available from police reports, mortuary data, and population surveys. Surveillance of trauma patients through hospital-based registries is shown to be effective but is not widespread in low- and middle-income countries.[9] Successful trauma databases have been implemented in hospitals in Uganda, where injury metrics relevant to Africa (the Kampala Trauma Score) were developed.[10] These efforts have been replicated in South Africa, including registries piloted at a regional hospital in Durban[11] and a primary emergency health care center in Tygerberg.[12] Both registries identified fewer than 1500 patients. The Trauma Bank project is a promising effort launched by the Trauma Society of South Africa, but it is not used at Groote Schuur Hospital (GSH) and failed to identify many persons who have experienced a traumatic event presenting to busy centers.[13] When it was tested at Johannesburg Hospital, another busy referral center, only 3400 patients were logged during an 18-month period.[14] There is also a paucity of published data from this registry.

Groote Schuur Hospital is a government-funded, tertiary teaching hospital situated in Cape Town, South Africa. It is the chief academic hospital of the University of Cape Town and one of the largest trauma referral hospitals in the world, with an estimated 12 000 patients being seen in the trauma unit annually. Some of the most severe injuries are seen at GSH, with almost 1 million more patients presenting at smaller sites throughout the city.[15] Our objective was to provide a sustainable strategy for trauma center–based injury surveillance that is integrated with clinical work flow, and that could be used to analyze injury data and access to trauma services in Cape Town.

Methods

Injury surveillance at GSH was developed in 3 parts. We first conducted a needs assessment with South African trauma surgeons, administrators, and public health officials regarding the utility and feasibility of implementing a trauma database. We estimated that a conventional trauma registry would cost $27 000 to implement, including data abstraction and analysis fees, and a similar amount to be maintained annually. Although the value of trauma data would probably justify this cost, we believed it would ultimately be prohibitive in most low- and middle-income countries.

Next, in conjunction with the staff of the trauma unit at GSH and injury prevention experts at the Medical Research Council of South Africa, a 1-page case report form was developed and was piloted as a forerunner for a future Cape Town Trauma Registry. To optimize data collection, there were no patient exclusion criteria. Captured data included patient demographics, injury mechanism and type, and geographic location of injury data. Ethics approval was obtained from the institutional review boards at Simon Fraser University and GSH. Patient consent was not obtained because the data sheets were used as part of the standard processes of care and recorded without identifying data in a trauma registry–type database.

After a 1-month pilot test of the case report form,[16] it was put into use as a trauma admission record (eFigure in the Supplement) in late 2010. Surgeons and medical house staff completed the admission records at the time of initial patient evaluation in the trauma bay. Data analysis was performed with Stata software (version 11.0; StataCorp), with ArcGIS software (version 9.2; Esri) used to illustrate the geographic location of injury.

Finally, to assess Cape Town's trauma system more thoroughly, we used the WHO trauma system maturity index tool to survey the trauma directors at both GSH and another large referral center, GF Jooste Hospital. This index allows universal comparison of trauma systems and indicates which actions are required to progress between levels of maturity.[17]

Results

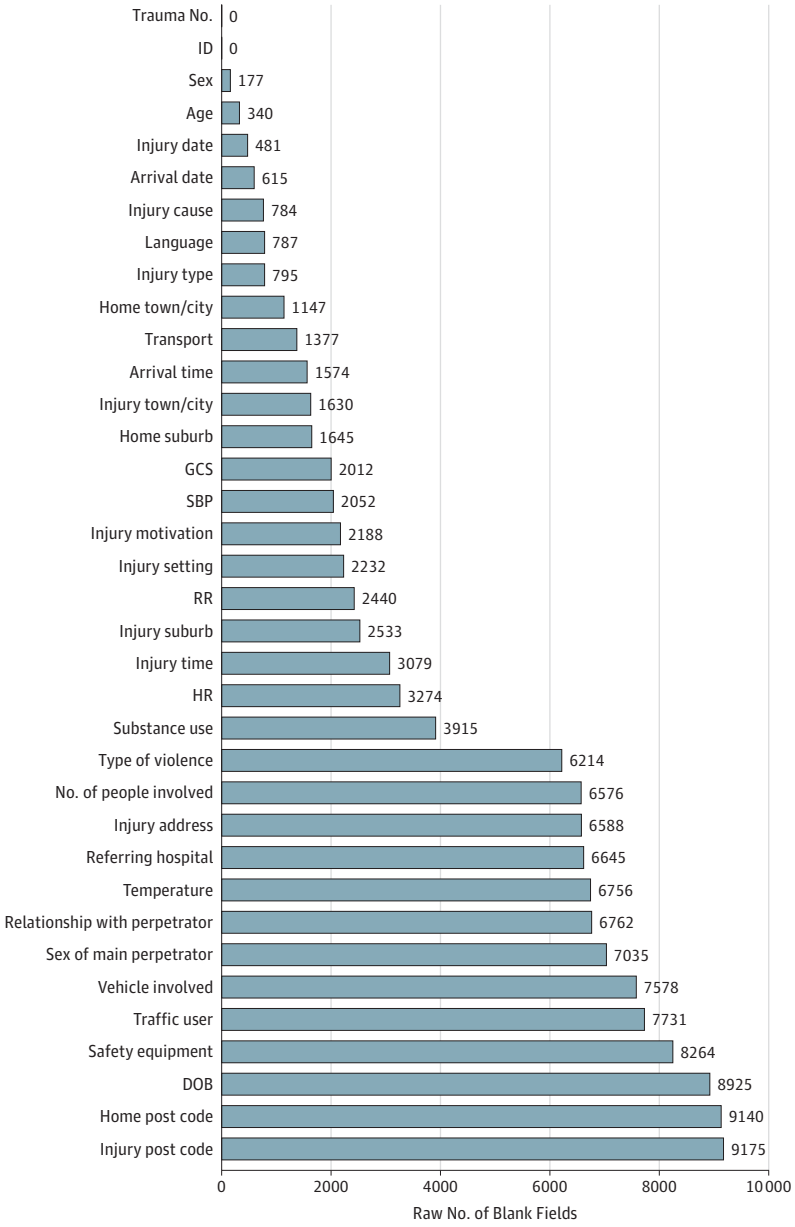
Form Use and Field Completion

The feasibility of use of the standardized clinical form as a registry tool was assessed by analysis of field completion rates. As illustrated in **Figure 1**, field completion rates for the 34 data points were quite variable. Patient demographics, including sex (98.1%) and age (96.3%), type of injury (91.4%), and location of injury (town, 82.3%; suburb, 76.8%), were most consistently recorded.

Patient Demographics

In our database, we registered 9236 consecutive patients during a 1-year period. Most violence occurred toward males (71.3%), and the age distribution was heavily weighted toward those at or younger than 40 years (74.6%; **Figure 2**). On arrival at the trauma bay, the mean patient temperature was

Figure 1. Number of Blank Fields for Each Data Point in Trauma Registry



Results are given for a total of 9236 patients. The field completion rate was quite variable; many public health data points, such as substance use and perpetrator information related to violent crime, were marked as unknown or left blank. DOB indicates date of birth; GCS, Glasgow Coma Scale; HR, heart rate; RR, respiratory rate; and SBP, systolic blood pressure.

36.4°C (range, 31.6°C-40.6°C), and the mean pulse rate 77/min (range 6-166/min). The mean Glasgow Coma Scale score was between 13 and 15; the mean respiratory rate, 10/min to 29/min; and the mean systolic blood pressure, greater than 89 mm Hg (these parameters were grouped into ranges).

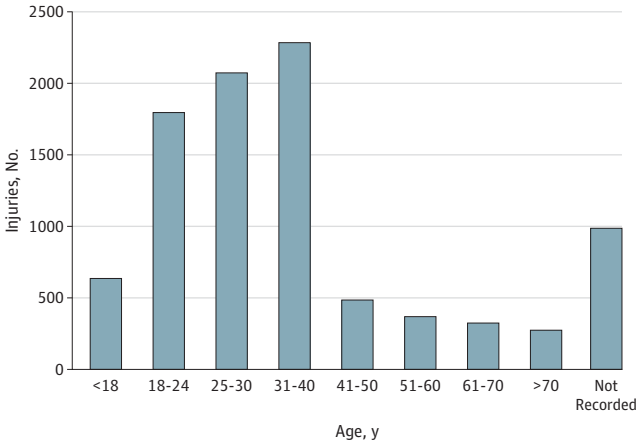
Injury Mechanism and Motivation

The most common mechanisms of injury include assault with a sharp (1933 [20.9%]) or blunt object (1571 [17.0%]), traffic collisions (1736 [18.8%]), and falls (1699 [18.4%]) (**Table**). Firearms accounted for only 442 (4.8%) injuries. Of the 1736 survivors of motor vehicle injury, the greatest number were pedestrians (807 [46.5%]), followed by passengers (600 [34.6%]) and drivers (324 [18.7%]) (Table).

Female patients were most susceptible to falls (34.9%), assault by sharp objects (11.9%), and traffic injuries (13.7%), with the highest incidences occurring in persons aged 25 to 44 years. For assault mechanisms, the perpetrator field was often left unreported. Male patients had higher percentages of injury caused by violent crimes: injury by firearm (8.1%), injury by sharp object (34.4%), or assault by a blunt object or physical beating (12.5%).

Our data showed a relatively even split between intentional (32.1%) and unintentional (33.2%) injury, but for many entries (34.7%) the intent was recorded as unknown. Most intentional violent crimes occurred because of interpersonal disputes (71.6%), assault within the community (10.1%), and gang-related violence (8.3%).

Figure 2. Distribution of Injuries by Age



Injuries have an age distribution weighted toward patient at or younger than 40 years.

There was a very low completion rate for substance use, with a blank field or an entry of "unknown" for substance use in more than 69.9% of the trauma records. Alcohol was implicated in at least 2788 (30.1%) trauma admissions, including 293 motor vehicle crashes (16.8%), 1316 assaults with sharp objects (68.1%), 361 assaults with blunt objects (23.0%), and 39 falls (2.3%) (**Figure 3**).

Geographic Distribution of Injury

The top 3 locations of injuries were on the street (3026 of 6226 [48.6%]), at home (2096 [33.6%]), and at a bar or shebeen (299 [4.8%]). The primary modes of transportation to the hospital were ambulance (51.1%), walking (18.2%), and private vehicle (14.7%).

Injuries were predominantly clustered in township areas of Cape Town such as Khayelitsha, Salt River, Landsdowne, and Mitchell's Plain (**Figure 4**). The main referring hospitals were Khayelitsha District Hospital (523 injuries [17.8%]), GF Jooste (517 [17.6%]), Victoria (508 [17.3%]), Guguletu (307 [10.4%]), Somerset (258 [8.8%]), and Woodstock (247 [8.4%]) (**Figure 5**).

Regional Trauma System

In conjunction with patient data collection, trauma directors at GSH and referral center GF Jooste were surveyed using the WHO trauma system maturity index tool. South Africa has a formal emergency medical service governed by a national agency and a universal access number available for emergency prehospital care. Community hospitals are equipped with health care personnel, including physicians, nurses, and medical officers who are trained to provide trauma resuscitation. Formal education and training is required to practice trauma, and a national licensing body provides trainee qualification. Facilities are accredited by a professional body (Trauma Society of South Africa). Referral services to secondary and tertiary care facilities are available in some regions but not universally. Quality improvement is primarily based on meetings to address morbidity and mortality at individual institutions. Despite previously developed registries, there have been no consistent attempts at documentation and analysis of data.

Based on the WHO trauma system maturity index, Cape Town has a strong trauma system, although some features have not been fully formalized. At the heart of the trauma system, GSH provided care for many patients, with 30% of its admissions originating from other regional hospitals. It can be considered a level I center, with specialized trauma care, processes for quality improvement, and strong commitments to education and research.

Discussion

Since the publication of *Accidental Death and Disability: The Neglected Disease of Modern Society* by the National Academy of Sciences in 1968,[18] fatalistic attitudes about injury risk and outcome have been transformed into dynamic public health approaches to injury control. Advances in injury prevention and constant improvements in the quality and coordination of pre-hospital care, acute in-hospital trauma care, and rehabilitation have reduced injury mortality rates,[19] and have created safer roads, work places, and societies in North America and around the world. This comprehensive public health approach to injury control, also known as *trauma systems*, if implemented even more widely, holds the promise of saving millions more lives[20] and significantly affecting the persistent and heavy global burden of injury.

The development of trauma systems is dependent on injury data and continuous injury surveillance. Few advances in injury control could be made without data collection and analysis. According to the WHO, "to develop effective injury prevention strategies, most countries need better information—innovative and novel tools are required to address this daunting task."[21] Unfortunately, surveillance data, in the form of trauma registries, have been difficult to implement in low- and middle-income countries, where the burden of injury is often the highest, due to cost and the urgency of competing priorities.

Even in Cape Town, home to one of the world's most experienced and academically productive trauma units, injury surveillance has been incomplete and inconsistent. Although

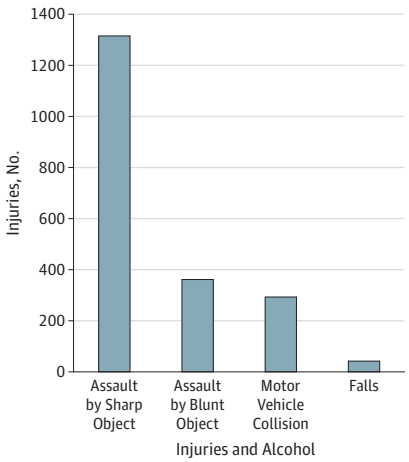
mortality data have been extremely helpful in South African injury research, they show only the tip of the iceberg that is the burden of injury. Analysis of trauma center data is essential to the completion of this picture. The cost of employing data analysts and maintaining electronic databases, and the sheer volume of trauma center admissions, however, has made effective injury surveillance a daunting task. We hoped to address the issues of data cost and patient volume by creating an admission record that could be filled out by frontline physicians and used for charting purposes but that also contained standardized fields relevant for injury prevention and scoring and could be collected continuously.

Table. Ten Most Common Mechanisms of Injury in 9236 Patients

Type of Injury	Injuries, No. (%)
Assault by sharp object	1933 (20.9)
Traffic collision	1736 (18.8)
Fall	1699 (18.4)
Assault by blunt object	1571 (17.0)
Assault by punching/kicking	495 (5.4)
Firearm	442 (4.8)
Bites (animal or human)	113 (1.2)
Crush	38 (0.4)
Strangling or hanging	10 (0.1)
Not recorded or unknown	795 (8.6)

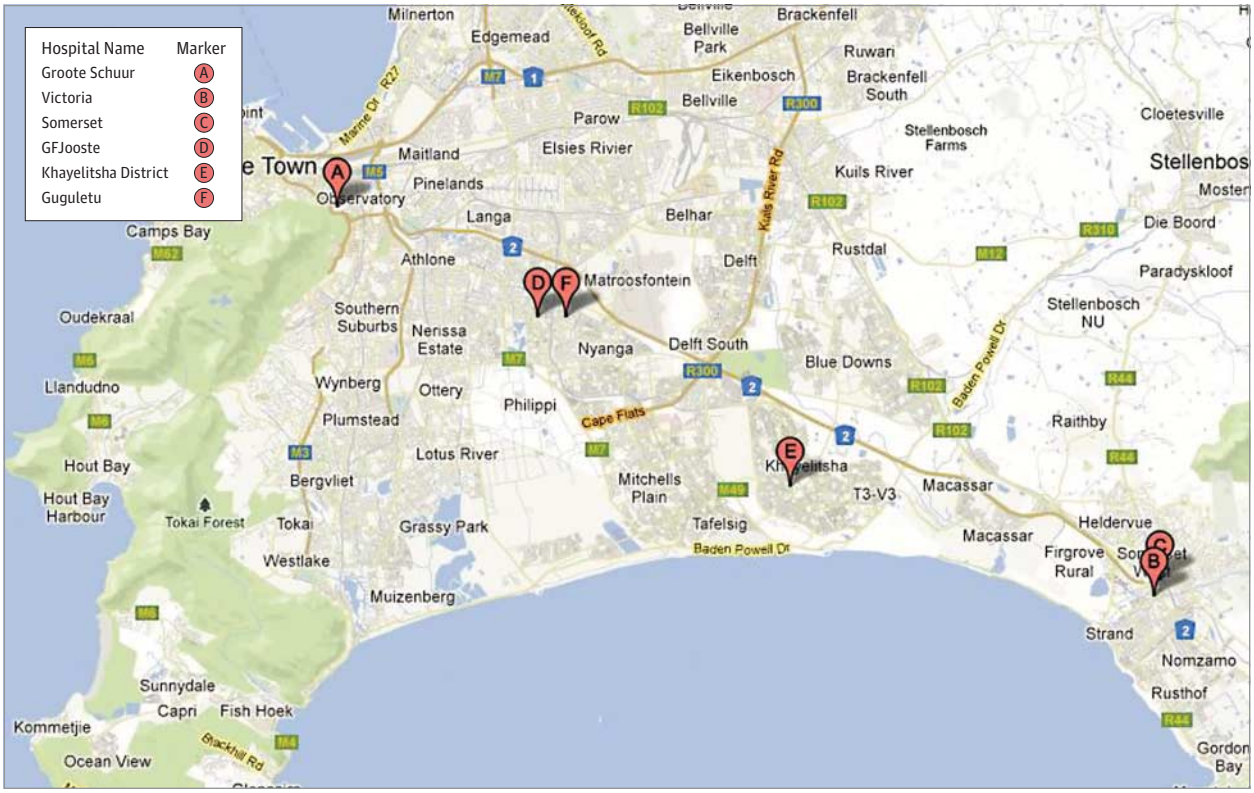
Our data confirmed the previously observed but incompletely quantified preponderance of young, male survivors of trauma and high rates of assault and violent crime. The data also demonstrate the strong association of alcohol and interpersonal violence, an important first step in the prioritization and development of effective injury control policy.[22] Traffic

Figure 3. Injury Motivation and Types of Intentional (Violent) Injury



Alcohol was implicated in at least 2788 trauma admissions, including many penetrating injuries.

Figure 4. Locations of Major Referral Hospitals



Mapping of the major hospitals and referral sites around Cape Town, South Africa.

Figure 5. Injury Hot Spots Surrounding Groote Schuur Hospital and Referring Hospitals

Mapping of injuries shows that they were predominantly clustered in township areas all over Cape Town, South Africa. North of the M2 Highway, all patients with trauma are transferred to Tygerberg Hospital, the other level 1 facility in Cape Town.

collisions also contribute to the burden of injury, and injury prevention efforts should account for the increased risk placed on pedestrians. These patterns in hospital-based data reinforce mortality statistics and serve to strengthen burden of injury and disability assessments. Geographic analyses of our data have begun to demonstrate injury "hot spots" that will allow for targeted placement of injury prevention efforts.

At the system level, our data set has allowed a few preliminary insights into the pattern of presentation to the hospital and the triage and flow of patients to higher levels of care. Such analyses are essential to the development and refinement of *inclusive* systems of trauma care, in which many hospitals play well-defined roles in trauma care and in which there is seamless coordination of trauma care between hospitals according to resources and expertise. There has been a movement toward more inclusive trauma systems where all acute care hospitals participate to the extent that their resources allow to improve quality of outcomes.[19] In the United States and Canada, trauma accreditation has shifted from evaluating specific trauma centers to review of trauma systems, whereby multiple levels of care facilities are assessed for their structure, process, and outcome. The evidence shows that burden of injury is better shared in inclusive systems, leading to improved outcomes. The most inclusive of trauma systems has shown the lowest odds of mortality (odds ratio, 0.77) after adjusting for injury mechanism and trauma system maturity.[19]

At present, the extent of "inclusivity" of South Africa trauma systems has been incompletely characterized. Many centers participate in initial trauma resuscitation and refer patients to GSH. The overall volume of referrals was high, and many patients referred to GSH arrived hemodynamically stable; it is therefore possible that they could have been adequately treated at their local facility. Further work would be needed to document the appropriateness of triage. This should stimulate review of transfer protocols and encourage expansion of resources at smaller hospitals located in injury hot spots.

There were inherent limitations in our admission record, and therefore in the study. Despite the initial recognition of the importance of completion of the admission records, field completion rates were low, probably because of frequent housestaff turnover and high clinical workloads. Ultimately, the tool was paper based and labor intensive for a very high-volume center that sees more than 12 000 trauma cases annually. Ongoing analyses are essential to determine which report field physicians are prepared to fill in, so as not to overburden medical practitioners with unnecessary data sheets. To encourage compliance, an on-site trauma coordinator would be ideal, and ongoing education would make some of the variables more meaningful for the user.

Our data included only admission information, so procedural data and outcomes remained unknown. This left us able to perform only demographic and geographic analyses, which,

although useful for future prevention efforts, provide only a glimpse of the burden of trauma. Anatomic information, which would have been useful for injury severity scoring, was also lost because of the way the registry form was split from the main medical record for purposes of subsequent analysis. Still, the above data collection provided some unprecedented glimpses into the burden of trauma and the structure of the trauma system in Cape Town. Each of these limitations points to exciting opportunities to improve injury surveillance within the regional trauma system.

To date, the majority of trauma trials conducted in Cape Town involved prospective data collection to study a specific question or program. Our efforts to create a more generalized database from which to extract information for multiple future studies were meant to ultimately minimize cost, improve efficiency, and provide the foundation for quality improvement and injury prevention.

The broadened and standardized data collection from our study has implications for various public health initiatives. The Safety and Violence Initiative at the University of Cape Town[23] and other established injury control programs could use surveillance data to develop and refine their approaches and target populations. As the capacity for injury surveillance grows, a key priority will be the routine collection and reporting of Injury Severity Score and Kampala Trauma Score data to permit more valid comparisons of outcomes within and between health care systems.

Soon, mobile information technology tools, such as smartphones, now widely available in Africa and around the world, will have the potential to revolutionize the way clinicians collect, interpret, and standardize data collection. We have designed a tablet computer–based electronic application that can be used by clinicians to simultaneously gather relevant patient data,[24] calculate injury severity scores, generate treatment plans, review safety checklists, and communicate plans. Clinician-entered data can simultaneously be uploaded in real time to a database, where software tools begin to generate analyses of quality of care and patient outcomes, for continuous quality improvement. This database can also be used to map injuries around cities and rural areas, identify hot spots, and guide health policy and injury prevention efforts. Ultimately, we hope that such low-cost information technology tools can expand the benefits of injury surveillance and corresponding trauma system development to low-resource settings, starting within the hospitals of Cape Town's trauma system.

Conclusions

According to the Director General of the WHO, Margaret Chan, "we must not forget that the real need is to close the data gaps, especially in low-income and middle-income countries."[25] Prospective trauma data collection can begin to close these gaps and can highlight both the epidemiology of trauma and opportunities to optimize the performance of trauma systems. Our injury surveillance project quantified volume of injury and patient flow in a mature trauma system. Ongoing surveillance has the potential to inform further formalization of processes of care, opportunities for formalized regional leadership, development of transfer protocols, and quality assurance and injury prevention at a system-wide level.

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Study concept and design: Nicol, Knowlton, Schuurman, Matzopoulos, Zargaran, Cinnamon, Taulu, Hameed.
Acquisition, analysis, or interpretation of data: All authors.
Drafting of the manuscript: Nicol, Knowlton, Matzopoulos, Hameed.
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