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ORIGINAL SCIENTIFIC REPORT

# The Hybrid Electronic Medical Registry Allows Benchmarking of Quality of Trauma Care: A Five-Year Temporal Overview of the Trauma Burden at a Major Trauma Centre in South Africa

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## Abstract

*Introduction* This study is a five-year follow-up of previously published review of the trauma workload at our institution. It aims to provide evidence about the quality of trauma care delivered by a major academic trauma service in South Africa to provide a temporal analysis of trauma trends in the city of Pietermaritzburg.

*Materials and methods* All trauma patients admitted by the Pietermaritzburg Metropolitan Trauma Service (PMTS) for the period December 2012-April 2018 were retrieved from the Hybrid Electronic Medical Registry (HEMR) for analysis.

*Results* Over the five-year period, a total of 8722 trauma patients were admitted to Grey's Hospital. There were 7242 (83.0%) males. The average age was 29.66 years. A total of 1719 (19.7%) patients less than 19 years of age, 377 (4.3%) older than 60 years of age and 1480 (17.0%) female patients were admitted following trauma. Table 3 breaks down the mechanism of trauma. A total of 5027 patients sustained blunt trauma (57.6%), and 3334 (38.5%) sustained penetrating trauma. A total of 4808 patients sustained intentional trauma implying that 55.1% of all trauma was secondary to grievous bodily harm or assault either in the form of a stab wound or GSW or of an assault. There was a total of 2232 road traffic-related incidents, of which 37.9% (845) were pedestrian victims. The mortality rate for all trauma admissions was 4.5% (396). Of these 396 deaths, 64 (16.2%) were classified at the morbidity and mortality conference as being avoidable.

*Conclusions* The HEMR has allowed us to track the burden of trauma presenting to our institution over a five-year period. This confirms previous studies over shorter time periods from our institution. The pattern of trauma has remained consistent, and the previously described high levels show no sign of decreasing. Interventions to try and reduce this burden are urgently required.

## Introduction

Trauma in South Africa was described as the 'malignant epidemic' three decades ago and the country continues to experience an excessively high burden of trauma, despite the advent of democracy over a quarter of a century ago [1–4]. The political response to this pandemic has been somnolent, ad hoc and lack-lustre. It has fallen to the trauma surgeons and clinicians under the umbrella of the Trauma Society of South Africa (TSSA) to provide leadership. The American College of Surgeons (ACS) over six

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decades ago recognized that whilst trauma is a surgical disease, it requires a public health type response. The ACS pioneered the concept of trauma centres, levels of care, and is the model in which modern trauma care is based [5]. Worldwide, this approach has repeatedly been shown to be highly effective at standardizing trauma care and of improving outcomes. The TSSA has been actively attempting to implement this approach in South Africa and has been accrediting trauma centres for over a decade [6]. One of the key components of a systematic response to trauma is the development of robust and sustainable tools to track the epidemic [7, 8]. The ACS has developed the National Trauma Databank (NTDB) in North America, which is the largest clinical repository of trauma patients in the world. Data are reported voluntarily from under one thousand trauma centres across North America. The data from the NTDB directly feeds into and informs ongoing quality improvement programmes such as the ACS Trauma Quality Improvement Program as well as academic research. The response to the need for trauma databases in South Africa dates back over three decades, and a number of researchers have produced valuable overviews of the burden of trauma [9–17]. These programmes include mortuary surveillance programmes in the Western Cape, the District Health Information System in Kwa-Zulu Natal as well as a number of paper systems based at individual hospitals [16, 17]. Over the last decade, there has been a move to develop electronic registries that harness modern information technology in a variety of innovative ways. These include the Medibank system in the central province of Gauteng, the electronic Trauma Health Record at Groote Schuur Hospital in Cape Town and the Hybrid Electronic Medical Registry (HEMR) at Grey's Hospital in Pietermaritzburg [18–22]. This study utilizes the data from the HEMR and is a five-year follow-up to earlier audits of the trauma workload in our institution which used data from the initial period of the HEMR [23–25]. The objectives of this study are to provide evidence about the quality of trauma care delivered by a major academic trauma service which may be used to inform the ongoing debate about the role of academic centres in South African health care and to provide a temporal analysis of trauma trends in the city of Pietermaritzburg.

## Materials and methods

### Clinical setting

Kwa-Zulu Natal is located on the east coast of the country and has a population of over 11 million people. Fifty percent of the population live in the rural areas. The PMTS provides definitive trauma care to the city of Pietermaritzburg, the capital of Kwa-Zulu Natal (KZN) Province. It is one of the largest trauma centres in the province and also serves as the referral centre for 19 rural hospitals within the province, with a total catchment population of over three million.

### Pietermaritzburg Metropolitan Trauma Service (PMTS)

The PMTS is an academic trauma centre run by three sub-specialist trauma surgeons. It provides academic training to medical students, surgical residents and to sub-specialist trauma fellows. The Hybrid Electronic Medical Registry (HEMR) is operated by the PMTS, which combines the functions of medical notes and a surgical registry. Clerking staff admit the patients on the HEMR. This consists of an interface with drop down options and spaces for free text. The entry is then printed out to serve as the patient's medical record, and the data are then captured into a relational database. The same process occurs following any operative or endoscopic procedure and on discharge. This unique system allows the PMTS to capture a comprehensive record of the patient's entire admission. There is an extensive quality control programme which consists of monthly workshops for the new rotating junior staff and daily reviews of the previous 24 hours data which are undertaken by dedicated and assigned attendings. This system has been extensively described in the literature.

### Morbidity and mortality conference

There is a dedicated module on the HEMR for recording all patient morbidity and mortality. The module has recently been updated to include the Dindo–Clavien grading for all morbidities and a taxonomy of error to classify each reported error. The data from this module are used to provide the weekly statistics for the morbidity and mortality conference. At this meeting, all deaths are classified using a quadratic grid into expected and unexpected and avoidable and unavoidable.

**Table 1** Yearly admission totals

| | |
|---|---|
| 2012 | 111 |
| 2013 | 1361 |
| 2014 | 1549 |
| 2015 | 1509 |
| 2016 | 1823 |
| 2017 | 1953 |
| 2018 | 413 |

Includes admissions from dates between 4 December 2012 and 11 April 2018

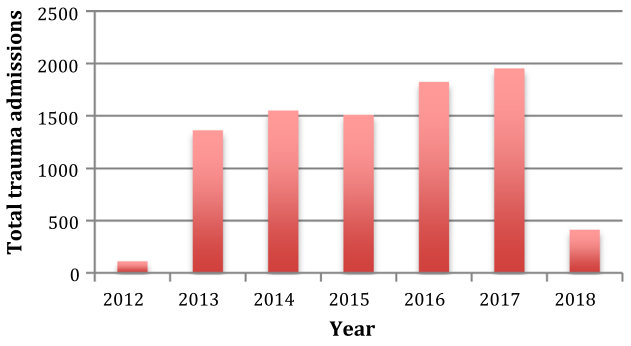


**Fig. 1** Yearly admission totals

**Table 2** Monthly admission totals

| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|
| January | | 101 | 99 | 106 | 171 | 189 | 117 |
| February | | 87 | 113 | 114 | 137 | 199 | 98 |
| March | | 138 | 148 | 140 | 136 | 230 | 149 |
| April | | 97 | 127 | 92 | 138 | 186 | 49 |
| May | | 113 | 127 | 104 | 111 | 176 | |
| June | | 113 | 112 | 116 | 142 | 132 | |
| July | | 86 | 145 | 152 | 146 | 135 | |
| August | | 93 | 138 | 154 | 141 | 108 | |
| September | | 124 | 132 | 106 | 149 | 139 | |
| October | | 119 | 132 | 116 | 171 | 120 | |
| November | | 129 | 109 | 147 | 126 | 159 | |
| December | 111 | 161 | 167 | 162 | 255 | 180 | |

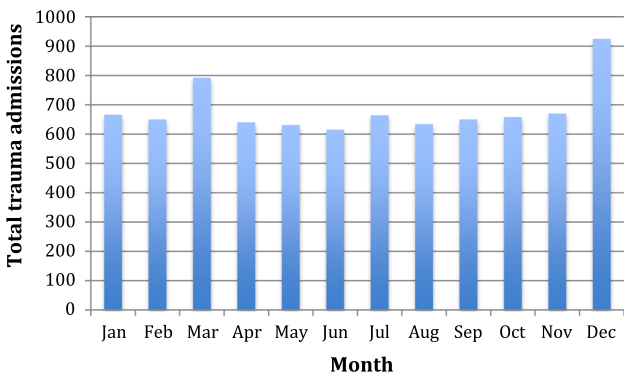


**Fig. 2** Fluctuation in admissions by month, 2013–2017. 2012 and 2018 were excluded from this chart, as there was not data available from every month

**Table 3** Classification of patients by age

| Age | Total | Percentage |
|---|---|---|
| 0–9 | 702 | 9.0 |
| 10–19 | 1017 | 11.7 |
| 20–29 | 3040 | 34.9 |
| 30–39 | 2212 | 25.4 |
| 40–49 | 917 | 10.5 |
| 50–59 | 414 | 4.7 |
| 60–69 | 253 | 2.9 |
| 70–79 | 87 | 1.0 |
| 80–89 | 31 | 0.4 |
| 90–99 | 6 | 0.1 |
| Not listed | 43 | 0.5 |

**Table 4** Classification of patients by gender

| Gender | Total | Percentage |
|---|---|---|
| Male | 7242 | 83.0 |
| Female | 1480 | 17.0 |

**Table 5** Classification of patients by ethnicity

| Ethnicity | Total | Percentage |
|---|---|---|
| African | 8124 | 93.2 |
| White | 161 | 1.8 |
| Coloured | 183 | 2.1 |
| Asian | 253 | 2.9 |

One patient ethnicity was not listed in their file

**Table 6** Mechanism of injury

| Mechanism | Total number | Percentage |
|---|---|---|
| Blunt trauma | 5027 | 57.6 |
| Penetrating trauma | 3334 | 38.2 |
| Bite | 152 | 1.7 |
| Burn | 14 | 0.2 |
| Combination | 133 | 1.5 |
| Unknown | 62 | 0.7 |

## The study

All trauma patients admitted by the Pietermaritzburg Metropolitan Trauma Service (PMTS) to Grey's Hospital

**Table 7** Subtypes of blunt trauma injury

| | |
|---|---|
| Assault | 1575 |
| Motor vehicle accident | 1387 |
| Pedestrian vehicle accident | 845 |
| Accidental fall | 363 |
| Fall from height | 211 |
| Unknown | 142 |
| Fall from moving vehicle | 117 |
| Accidental injury | 80 |
| Hanging injury | 72 |
| Motorcycle accident | 60 |
| Collapse of building structure | 54 |
| Fall from bicycle | 48 |
| Sport injury | 31 |
| Animal injury | 25 |
| Combination | 17 |
| Other | 2 |

**Table 8** Subtypes of penetrating trauma injury

| | |
|---|---|
| Stab wound | 2201 |
| Gunshot wound | 1028 |
| Impalement | 58 |
| Accidental laceration | 21 |
| Animal injury | 12 |
| Unknown | 7 |
| Combination | 5 |

for the period 4 December 2012 to 11 April 2018 were retrieved from the HEMR for analysis.

## Results

Over the five-year period, a total of 8722 trauma patients were admitted to Grey's Hospital. Table 1 and Figure 1 break down the admission per year. Table 2 and Figure 2 show the monthly admissions for the five-year period. Figure 2 excludes data from the years 2012 and 2018, as not all months in those years were included in the analysis. Tables 3, 4 and 5 show the age distribution as well as the breakdown of the gender and ethnicity, respectively. There were 7242 (83.0%) males. The average age was 29.66 years. A total of 1719 (19.7%) patients less than 19 years of age, 377 (4.3%) older than 60 years of age and 1480 (17.0%) female patients were admitted following trauma. Table 6 breaks down the mechanism of trauma. A total of 5027 patients sustained blunt trauma (57.6%) and 3334 (38.5%) sustained penetrating trauma. A total of 4808 patients sustained intentional trauma implying that 55.1% of all trauma was secondary to grievous bodily harm or assault either in the form or a stab wound, GSW or blunt force assault. There were a total of 2232 road traffic-related incidents of which 37.9% (845) were pedestrian victims. Tables 7, 8, 9, 10 and 11 break down the mechanisms of

**Table 9** Weapons used in penetrating trauma injuries

| | |
|---|---|
| Knife | 1338 |
| Low velocity firearm | 600 |
| Bush-knife | 174 |
| Bottle | 129 |
| High velocity firearm | 82 |
| Axe | 37 |
| Screwdriver | 31 |
| Broken glass | 27 |
| Spear | 25 |
| Wooden object | 12 |
| Industrial implement | 10 |
| Scissors | 8 |
| Combination | 8 |
| Wire | 5 |
| Metal object | 27 |
| Other | 12 |
| Total | 2525 |

**Table 10** Weapons used in blunt trauma assaults

| | |
|---|---|
| Wooden rod | 182 |
| Stones | 153 |
| Brick | 89 |
| Metal rod | 78 |
| Bottle | 49 |
| Combination | 44 |
| Sticks | 41 |
| Sjambok | 40 |
| Knobkerrie | 35 |
| Hammer | 32 |
| Bush-knife | 27 |
| Back of gun | 15 |
| Spade | 11 |
| Golf club | 11 |
| Knife | 5 |
| Axe | 5 |
| Metal rod | 4 |
| Other | 19 |
| Total | 840 |

**Table 11** Subtypes of bite injuries

| | |
|---|---|
| Snake | 132 |
| Dog | 16 |
| Human | 3 |
| Spider | 1 |
| Total | 152 |

**Table 12** Classification of injury severity scores

| | |
|---|---|
| Median ISS | 9 |
| IQR | 9 |
| Total ISS listed | 6603 |

**Table 13** Classification of injuries by anatomic region

| | |
|---|---|
| Abdomen | 2213 |
| Extremity | 2660 |
| Head | 4386 |
| Maxillofacial | 1841 |
| Neck | 1286 |
| Pelvis | 582 |
| Peritoneum | 113 |
| Thorax | 2628 |

**Table 14** Classification of abdominal injuries

| | |
|---|---|
| Soft tissue injury | 1505 |
| Musculoskeletal injury | 693 |
| Vascular injury | 47 |
| Oesophageal injury | 2 |
| Gastric injury | 170 |
| Duodenum injury | 65 |
| Small bowel injury | 381 |
| Large bowel injury | 285 |
| Rectal bowel injury | 39 |
| Solid organ injury | 740 |
| Biliary injury | 22 |
| Urogenital injury | 134 |

trauma in our series, and Table 12 shows the ranges of injury severity scores (ISS). The median ISS was 9. Tables 13, 14, 15, 16, 17, 18, 19, 20 and 21 break down the injuries according to body region. Table 22 describes the surgical interventions by anatomic region, and Tables 23

**Table 15** Classification of extremity injuries

| | |
|---|---|
| Upper limb soft tissue injury | 1307 |
| Upper limb musculoskeletal injury | 652 |
| Upper limb vascular injury | 159 |
| Upper limb nerve tissue injury | 85 |
| Lower limb soft tissue injury | 1140 |
| Lower limb musculoskeletal injury | 775 |
| Lower limb vascular injury | 118 |
| Lower limb nerve tissue injury | 12 |

**Table 16** Classification of head injuries

| | |
|---|---|
| Soft tissue injury | 2930 |
| Musculoskeletal injury | 1733 |
| Focal brain injury | 2273 |
| Diffuse brain injury | 682 |
| Neurologic injury | 208 |

**Table 17** Classification of maxillofacial injuries

| | |
|---|---|
| Soft tissue injury | 1437 |
| Musculoskeletal injury | 755 |
| Maxillary fracture | 111 |
| Nasal injury | 174 |
| Orbital injury | 444 |
| Nerve tissue injury | 31 |

**Table 18** Classification of neck injuries

| | |
|---|---|
| Soft tissue injury | 846 |
| Musculoskeletal injury | 477 |
| Airway injury | 50 |
| Vascular injury | 164 |
| GI tract injury | 66 |
| Nerve tissue injury | 96 |

**Table 19** Classification of pelvic injuries

| | |
|---|---|
| Soft tissue injury | 251 |
| Musculoskeletal injury | 401 |
| Nerve tissue injury | 2 |
| Vascular injury | 18 |

**Table 20** Classification of perineum injuries

| | |
|---|---|
| Genital injury | 86 |
| Anal injury | 28 |

**Table 21** Classification of thorax injuries

| | |
|---|---|
| Soft tissue injury | 1681 |
| Musculoskeletal injury | 1067 |
| Airway injury | 10 |
| Vascular injury | 77 |
| Cardiac injury | 79 |
| Lung parenchyma injury | 1492 |
| GI tract injury | 10 |
| Nerve injury | 72 |

**Table 22** Surgical procedures by anatomical region

| | |
|---|---|
| Abdomen | 1074 |
| Extremity | 488 |
| Head | 256 |
| Maxillofacial | 92 |
| Neck | 96 |
| Pelvis | 48 |
| Perineum | 25 |
| Thorax | 311 |
| Total | 2930 |

**Table 23** Clinical outcomes of patients

| Clinical outcome | Total number | Percent |
|---|---|---|
| Survived | 8152 | 93.5 |
| Died | 396 | 4.5 |
| Unable to determine from file | 174 | 2.0 |

**Table 24** Classification of deaths

| | |
|---|---|
| Avoidable—Expected | 17 |
| Avoidable—Unexpected | 47 |
| Unavoidable—Expected | 238 |
| Unavoidable—Unexpected | 52 |
| Not listed | 42 |

and 24 show the patient outcomes. The mortality rate was 4.5% (396). Of these 396 deaths, 64 (16.2%) were classified at the morbidity and mortality conference as being avoidable.

## Discussion

Three decades ago, trauma in South Africa was labelled the 'malignant epidemic' and contemporary South Africa continues to experience an excessive burden of trauma. South Africa, whilst is a High Middle Income Country (HMIC), has huge disparities in wealth and access to health services. It has well-respected academic centres with a proud history of delivering trauma care, contributing to the international literature on trauma and providing leadership for trauma care (1–30) The trauma centre has expertise which must provide support in a spoke and wheel type approach to lower levels of care which reach all the way into the community [5, 6]. The political conflict in South African health care has tended to revolve around the pull between the large urban centres of expertise which have traditionally been well funded and staffed and the peripheral institutions closer to the community. The public health approach which was adopted with the advent of democracy has tended to be suspicious of the large central institution and instead favours the smaller more rural institutions. As the ACS has shown with their adoption of a trauma systems approach, this is a false dichotomy based on a faulty premise and inadequate evidence [5, 6]. Without strong central institutions, the periphery cannot function and this is particularly the case with trauma. The development of sophisticated HEMR has allowed us to accurately quantify the burden of trauma and the impact of a major trauma centre on outcomes for trauma [24, 25].

This data set provides a broad overview of five-year workload of a major trauma service in South Africa. The demographics of this cohort are very much in keeping with what is understood about trauma, with the majority of patients being young African males in their productive years. Over half of all trauma was secondary to grievous bodily harm or assault either in the form of a stab wound or GSW. The mechanism in Pietermaritzburg differs to that reported from the Western Cape as blunt trauma accounts for slightly under 60% of all trauma and penetrating trauma just under 40%. However, 31% of all blunt trauma-related injury is secondary to assault [26].

There are specific vulnerable groups of patients who sustain trauma yet who have not been the focus of much violence and trauma research in South Africa [16–18]. These include women, children and the elderly. In this five-year period, 20% of all trauma victims were less than 19 years of age, 16% were females and 4% were over the age

of 60. These groups collectively comprise a significant cohort of vulnerable patients. There is almost no literature on these groups in particular, and more research must be undertaken looking at the spectrum and outcome of trauma in these groups. Another group of at risk patients is those with suicidal ideations, and the PMTS treated 72 hanging survivors over the five-year period.

The strategic response to the trauma epidemic must be a trauma systems approach, which integrates the various arms of the response [4–7]. The curative service is an important component and it would appear that the tertiary service provided by the PMTS is meeting the service demands. The mortality rate is 4.5%, which is in keeping with the rates published by North American Trauma centres [4, 5]. Of concern is the 16% of deaths that are thought to have been avoidable. The curative arm of the service, however, also includes the rural district hospitals and the Emergency Medical Rescue Service, and our data does not reflect on the quality of these services. More detailed work must be undertaken to investigate their role in the system of care and their outcomes. To this end, mortuary surveillance is necessary to complement the data from the HEMR [17, 18, 27].

The other arm of the strategy must comprise injury prevention programmes. These need to be tailored to the evidence. Vulnerable groups such as women, children, mental health care users and the elderly deserve dedicated programmes. Road traffic accidents (RTA) continue to be a major burden. Injury prevention programmes need to address this. Of note 38% of the RTA were pedestrian related. Efforts must be directed towards improving pedestrian safety. Dealing with interpersonal violence calls for major multifaceted interventions. These will have to include the community, the police, non-governmental organizations and private business. Some such interventions have begun to be rolled out in the Western Cape and these need to be extended to other parts of South Africa.

## Conclusions

The HEMR has allowed us to track the burden of trauma presenting to our institution over a five-year period. This confirms previous studies over shorter time periods from our institution. The pattern of trauma has remained consistent, and the previously described high levels show no sign of decreasing. Interventions to reduce this burden are urgently required. The trauma systems approach to the problem of trauma and injury needs to be strengthened.

**Compliance with ethical standards**

**Conflicts of interest** All authors declare that they have no conflicts of interest

**Ethical approval** Ethics approval for this study and for maintenance of the registry was formally endorsed by the Biomedical Research Ethics Committee (BREC) of the University of Kwa-Zulu Natal (reference: BE 207/09).

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