SPECTRUM AND COST OF ROAD TRAFFIC CRASHES: DATA FROM A REGIONAL SOUTH AFRICAN HOSPITAL

By

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As the candidate’s supervisor I have/have not approved this thesis for submission.

Signed: _____________ Name: _____________ Date: ____

Dedication

This work is dedicated to its Editor, Clare Parkinson.

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I, Fran Parkinson, declare that

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Summary

Road traffic crashes (RTCs) are a worldwide phenomenon, but a disproportionate number of deaths and injuries caused by RTCs occur in developing countries. A number of international organisations have drawn attention to the problem and called for a comprehensive public health response. Such a programme needs to be multi-faceted and use preventative and therapeutic strategies and also involve a wide range of stakeholders from government and civil society. In South Africa, the Province of KwaZulu-Natal (KZN) has the worst record for the number of deaths and injuries sustained on the roads. Despite the urgent need for such programmes in the Province there is a paucity of local research on the problem.

This project sees itself as part of an ongoing systematic comprehensive quality improvement initiative. The objectives of this single-centre study are to determine common patterns of injury associated with road traffic crashes in KZN, to identify risk factors which may be targeted by specific injury prevention programmes and to establish the in-hospital cost of RTCs. This will be done by identifying a cohort of patients with injuries sustained in RTCs, gathering data on their injuries and circumstances of the crash, and costing their inpatient stay using micro-costing methods. It is hoped that this information on the burden of disease (including cost) will be incentive for investment in local healthcare and risk-reducing measures (relevant to local risk factors). The costs may also serve as a baseline for larger province-wide costing studies.

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CHAPTER ONE: INTRODUCTION

Road traffic injuries are a major but neglected global public health problem. In 2009 road traffic crashes (RTCs) were the 9th leading cause of death worldwide, with more than 1.2 million deaths reported annually. In terms of non-fatal injuries, 20–50 million injuries are caused by RTCs annually. In 2002 RTCs were the 9th leading global cause of disability adjusted life years (DALYs) lost.(1) The UN has expressed concern at the increase of traffic fatalities and injuries worldwide since the 1970s, and in their 2003 resolution remained convinced that RTCs are a major public health problem, requiring concerted efforts for effective and sustainable prevention.(2)

This morbidity and mortality is not evenly distributed – over 90% of the total deaths and 96% of the paediatric deaths occur in low- and middle-income countries, though these countries only have 48% of the world's registered vehicles. While the number of RTC fatalities is predicted to decrease by up to 30% in high-income countries by 2020, there is expected to be a huge escalation of fatalities in middle and low income countries that are rapidly becoming more motorised. By 2030 it is predicted that RTCs will be the 5th leading cause of death, ahead of diseases such as HIV/AIDs and TB. In terms of non-fatal crashes, by 2020 it is predicted that RTCs will rank 3rd as the cause of DALYs lost.(1)

South African statistics have confirmed the WHO predictions about the increased use of motorised transportation in the developing world by demonstrating a steadily increasing number of registered vehicles and drivers.(3) It has been estimated that there were 13,802 deaths from RTCs in 2011 in South Africa – 27.5 per 100,000 population.(3) This is almost triple the number of deaths in the US during the same period (10.4/100,000 population).(4)

Of the nine South African provinces, KwaZulu-Natal has the highest number of fatal crashes and fatalities, and the highest number of reported traffic offences. It has the 3rd highest number of registered vehicles and the 2nd highest number of non-roadworthy and unlicensed vehicles. Despite national efforts to improve road safety, KwaZulu-Natal has consistently been the worst performing province in terms of reducing the number of RTC-associated fatalities in South Africa.(3, 5)

In a seminal paper in 1990, Professor Muckhart recognised the problem of road trauma in South Africa as an ever-growing burden on the health service.[6] In his descriptive paper focusing on trauma in KwaZulu-Natal, Muckart described trauma as a malignant epidemic. He described three phases in which mortality from RTCs occurs, and suggested that death in each phase can be prevented with appropriate research and focused improvements.

Phase one deaths and crash prevention

Phase one includes immediate death or death in the period shortly after the crash. There is little that can be done to prevent these deaths once the injury has occurred, so the key to reducing the number of deaths in this phase is preventative road safety measures. There are unique risk factors for road crashes in developing countries (particularly rural areas) that need to be controlled.

In 1997 Odero reviewed 73 descriptive epidemiological studies of RTCs in developing countries.[7] His work demonstrated that men, young people and pedestrians are most likely to be involved in RTCs in developing countries. He postulated that the high level of pedestrian involvement may be due to lack of pedestrian facilities in road design, poor knowledge and practice of road safety measures, discourteous motorists and high-speed driving. He suggested that detailed data indicating characteristics of road users at regional level is needed due to the likelihood of within-country differences, and that road safety measures transferred from one country to another need to be adapted and targeted to the specific risks of a given country. The limitations of under-reporting of non-fatal injuries and therefore a lack of denominator data were recognised.

A review by Nantulya in 2002 also concluded that young people and pedestrians are particularly at risk in developing countries.[8] The paper identified five reasons for the increasing burden of mortality from RTCs in developing countries: the increase in vehicle ownership, the common use of minibuses and trucks, with consequent higher number of people killed or injured per crash, poor enforcement of traffic safety regulations (including corruption of authorities), inadequacy of public health infrastructure and poor access to healthcare. Again, this review highlighted the need for policies on traffic safety to be based on local evidence and research on particular social and economic circumstances in the area involved in order to be effective.

Hazen also reviewed risk factors pertaining to developing countries, and discussed potential barriers to preventative interventions that have been successful in developed countries.(9) In developed countries there has been a paradigm shift in thought towards road safety. A systems-based approach has been adopted, leading to observation of interactions between the road user, the vehicle and road environment, identification of risk factors and a strategy of addressing these factors with appropriate interventions. This replaces the previous attitude of attributing a crash to a single driver/pedestrian error.

However Hazen's paper points out the differences between developing and developed countries and suggests that risk management requires different strategies. For example, seatbelts have been proven effective in decreasing death and severe injury for motor vehicle occupants. It is estimated that less than half of vehicles in developing countries are fitted with functional seatbelts. There is also a lack of enforcement of seatbelt laws. Therefore alternative strategies to mandating usage would be banning the importation of vehicles without functional belts, or at least mandating usage in public transport vehicles. To protect vulnerable pedestrians, wide sidewalks with raised kerbs are an effective and relatively inexpensive measure, though installation must be accompanied with sufficient education in order to change cultural tendencies regarding road safety.

Regarding vehicle factors, there has been one study in South Africa looking at the contribution of mechanical failures to RTCs and comparing them to international trends.(10) This was a prospective study of data from crash response units, and roadside surveys. The study was limited as the crash report database did not have information on crashes that didn't involve the police, or that didn't involve fatalities. It was also difficult to determine whether a mechanical failure was the primary cause of the crash or an incidental finding. In the study 157 vehicles were tested on the roadside for potential mechanical defects, and 60 minibus taxis tyres were checked. They found that 40% of vehicles surveyed on the suburban road and 29% of vehicles on the highway had mechanical defects that contravened current road regulations in

South Africa. There were large irregularities in tyre inflation pressure in minibus taxis, but up to 50% were under-inflated.

Collectively these papers highlight the differences between risk factors in developed and developing countries, and the need for these to be considered in order to make interventions most effective. There is an abundance of national statistics regarding RTCs in South Africa – using data from the police, provincial traffic authorities, traffic offence surveys and Statistics South Africa.(3,5,11,12) However, the availability of this information does not seem to be useful in controlling the growing problem of RTCs in KwaZulu-Natal, which, despite national road safety campaigns, has consistently been the worst performing province in terms of reducing the number of RTC-associated fatalities. The current literature suggests that more research at a local or regional level to determine the burden of disease and locally relevant risk factors would be one key step in developing effective road safety interventions.

The second important step is to motivate decision makers to address the problem of RTCs and invest in preventative measures. Hazen's review of potential barriers to road safety states: 'Political will may be the most important barrier. Without the commitment of governments, little action will be taken.' In addition to the primary concern of loss of life, pain and suffering caused by RTCs, the cost of RTCs is a significant burden on the economy. Using the 'human capital' method, the economic burden of road traffic crashes to KwaZulu-Natal is 4.5% of GNP, which is among the highest in the world.(13)

The cost of RTCs should be a powerful stimulation to budget-focused governments, particularly in developing countries where appropriate resource allocation is critical. Costing has already been successfully used in South Africa as a tool to lobby and advocate for improved prevention initiatives in the HIV/AIDS pandemic. Accurate RTC costing has the potential to facilitate appropriate resource allocation and also aid measurement of the cost-effectiveness of preventative measures.

Bowman reviewed the state of injury costing in South Africa in 2004.(13) Costing in the public sector is well behind that of the private sector – consisting of a small number of relatively fragmented and highly specific studies. Improvement will require specific costing tools, personnel training and a shift towards a culture of rigorous costing. Government involvement would help negotiate these infrastructural difficulties, however the current studies do assist in laying the foundation of a national costing system.

Indirect costs (e.g. loss of income) are generally greater than the direct costs (medical costs, property and vehicle damage costs). The best methodology for calculating indirect costs is debatable and under-researched in developing countries. The most accurate method of calculating direct costs has been shown to be micro-costing (or 'bottom-up costing') – quantifying each cost driver to calculate a total cost per unit. However this is time-consuming and labour-intensive. The alternative method for calculating direct costs is top-down costing: using the total expenditure divided by the number of units to create an average cost. The most comprehensive South African costing study used national 1998 road traffic collision data to estimate the unit cost per road traffic collision.(14) They used data from Statistics South Africa, insurance companies and the Road Accident Fund. They estimated the unit collision cost to be R24,817. This was inclusive of loss of output, property damage, pain and suffering, hospital and medical costs, and administration and legal costs. The average medical costs per collision (calculated using the top-down method) were R1,912.

There are three other South African costing studies for RTCs. Olukoga also used 1998 data, from the Department of Transport.(15) The hospital costs were described as being 'based on the costs incurred for the treatment of casualties', but the specific sources and inclusions are not explained. The costs were given as a total per driver – the hospital and medical costs contributed between 0% and 18.2% of the total cost per crash, depending on severity. The other costing study is the only other published study to use micro-costing methods.(16) However it is a pilot study, and included only 14 RTC patients. It calculated the cost of consumables used in the emergency department, general wards and in theatre when treating these patients. It did not include ward and theatre overheads, operating time, radiological or pathological investigations or orthopaedic implants. Their total cost of consumables per patient was R3,885. The third costing study was a retrospective record review of orthopaedic trauma patients attending a secondary-level hospital in Durban.(17) A profile of a ‘typical case’ according to body region injured was created and costed. The costs for each group were then added to get a total cost of care. Only patients that were operated on were included, and treatment in the intensive care or trauma unit wasn’t included. The total cost for the year was R5,440,964. A comparison was made with the costs calculated using a top-down method on the same patients, and the difference between estimates was shown to be up to 20%.

Phase two deaths and efficient medical care

In Muckart’s paper the second phase of mortality is described as the period of a few hours after the crash has occurred. This time is known as the ‘golden hour’, and it is here that efficient and adequate medical resuscitation of patients will make the difference between life and death. The key determinants here are pre-hospital care, access to facilities, and appropriate triage and rapid assessment of these patients. Again in developing countries, access to healthcare can be limited and research into the extent of this problem could be useful in resource planning. Knowing typical patterns of injury to expect, depending on mechanism of injury, will help receiving medics to initiate appropriate investigations and to begin treatment promptly.

Muckart’s descriptive paper highlighted the problem of crashes in rural areas – in 1985 there was a 1:4 chance of death from an injury sustained in a RTC in a rural area, compared to a 1:14 chance of death from a similar injury in an urban area. For serious injuries the likelihood was 1:1 and 1:3 respectively. There are a few reasons for this: rural collisions tend to involve higher speed, the average response time for ambulance personnel to reach a rural crash is double that for urban collisions, and definitive hospital care often doesn’t exist in rural areas.

Access to healthcare ultimately needs to improve, however for as long as a prolonged transfer from the scene of the crash can be expected, the onus is on the receiving medical team to be able to rapidly assess these patients, and initiate prompt referral or management. Enabling this is the ability to predict injury patterns according to the mechanism of injury. Despite a number of papers describing the differences between the risk factors and mechanisms of RTCs in developing countries compared to the developed world, and the high burden of disease in South Africa, there is no South African literature on the common patterns of injuries seen.

Two retrospective studies in the US of 5,000 and 115 pedestrian patients respectively both showed that musculoskeletal injuries were most common, followed by head and neck injuries. [18,19] The larger study showed that the lower extremity was most commonly injured and had an overall mortality rate of 7.7%. The smaller and older study had an overall mortality rate of 22% but again showed that tibia-fibula fractures were most common.

Another retrospective study of 180 patients in Sydney again showed that musculoskeletal and then head injuries were most common.[20] Their mortality rate was 8.9%. They described three phases of pedestrian injury – the first as they impact the bumper and injure the lower limbs, the second and third as they impact against the bonnet and windscreen, and then the ground or another object. In the second and third phases head and torso injuries occur.

There are two prospective studies from the UK, both showing the same findings of lower-limb and head injuries being the most commonly injured in pedestrian crashes. [21,22] There is one study of both pedestrian and motor vehicle occupants which demonstrated that pedestrians suffered more severe injuries, were more likely to be admitted to hospital, and were more likely to undergo surgery and spend longer in hospital.[23]

The structure of this thesis

This thesis is a thesis by publication comprising three publications. Chapters 2 – 4 include the papers and are prefaced by a discussion around each research question. The final chapter of this thesis shows limitations of the study and offers thought on how this study informs future research into road traffic crashes in South Africa.

Ethics

This study under the Biomedical Research Ethics Committees approval BE 207/09. See Appendix 1 for details.

CHAPTER TWO: THE LOCAL BURDEN OF DISEASE: MORTALITY, MORBIDITY AND RISK FACTORS

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Over a ten week period 305 patients were seen at Edendale hospital following a RTC, and 100 of these were admitted. Extrapolating our data to a year would suggest that we should expect a total of 1,664 patients a year with 520 requiring admission. This equates to five RTC victims every day.

There were 45 fatalities from RTCs recorded at the police mortuary over the same time period. The 13 mortalities from other hospitals in the area were excluded from our analysis. The on-scene mortality rate was 5% and the overall mortality rate was 10%. This translates into a RTC-related fatality every second day.

In his seminal paper on RTCs, Muckart describes phase one deaths as those occurring on scene, immediately after, or within a short period after the crash. In his paper, he explains that these deaths cannot be prevented once the crash occurs.(6) However, we had data on the time between the crash and arrival to hospital in 30 of our patients, and the average length of time it took to bring these critically ill patients to hospital was 9.2 hours. In the current situation it may therefore be sensible to divide phase one deaths into immediate and early, and hypothesise that better, and faster, pre-hospital care might prevent some of the ‘on-scene deaths’ seen in our study.

The incidence of non-fatal injuries was compared with European statistics. An injury pyramid of minor, moderate and severe injuries demonstrated that the number of moderate and severe injuries was over double that expected for the same number of minor injuries seen in a European country. The number of fatalities was almost ten times the number expected for the same number of minor injuries in Europe. The higher incidence and increasing prevalence of fatalities from road traffic crashes in developing (compared to developed) countries has been well described previously.[24,25] Data such as ours demonstrating non-fatal RTC injuries (categorised by Injury Severity Score) is rarely collected on a national scale as RTC data is typically derived from police reports, which describe fatalities but fail to describe accurately non-fatal injuries.[25] Another perspective on the injury pyramids is gained by estimating the number of non-fatal injuries expected according to the number of fatal injuries recorded. This pyramid demonstrates that for the number of fatalities seen in the Edendale district, a European hospital would expect to see 1,600 minor injuries (192 were seen at Edendale). It could be postulated that not only are RTCs in this district associated with more severe injuries, but that many patients with only minor injuries would not present to our hospital. This could be due to stoicism, limited transport, or because they received treatment from traditional healers or local clinics instead.

Pedestrian patients were significantly younger than motor vehicle occupants (average age 26.2 years, 31.4 years, P=0.0099). Of all the patients (admitted and non-admitted), 16% were aged 15 years or under. Of the admitted patients 24 were full-time students, and they lost on average 16 days of study due to hospitalisation (not including rehabilitation after discharge). A total of 67 patients were of an economically productive age, and 30 of these patients were in employment and lost on average 22 days from work due to hospitalisation alone.

Risk factors

Causes of RTCs can be broadly classified into three areas: human, environmental and vehicle factors. The most common causes vary in different countries and even in regions within a country. However, human error is universally the most common factor involved.[24] This includes errors such as excessive speed, use of alcohol, driving too close to other road users. Traditionally this has led to theories of education and publicity being the backbone of road safety policy, in order to persuade road users to adopt ‘error free’ behaviour. This has largely been unsuccessful. Therefore the more modern approach has been to accept human error as part of the human condition and instead aim to design systems that have an in-built tolerance of human error. For example: the speed at which a car is driven is decided by the driver, and he may make the error of driving too fast – a known risk factor for an RTC. However, the speed at which he chooses to drive is influenced by a number of factors including the layout of the road, surrounding environment, lighting, signage and local enforcement of speeding regulations. These can all be planned for and adapted to create a low-risk environment.

As well as a tolerance of human error, there needs to be an acceptance of the physiological human limits: first regarding driving ability, and secondly regarding the biomechanics of an RTC and susceptibility to injury. For example, a driver's vision is naturally reduced at night, and limited at the peripheries of vision. Road layout and lighting can be altered to account for this. Secondly, the human body's tolerance to impact is limited. However, vehicles can be designed – both inside and out – to improve this tolerance: bumpers can reduce impact and seatbelts can be worn to reduce deceleration injuries. Roads can have inbuilt measures to reduce contact between motorised vehicles and pedestrians.

All of these interventions are costly. Therefore, in order to be cost-effective, these interventions should be targeted to meet local needs, and research such as ours into locally relevant risk factors is imperative.

One quarter of the crashes our cohort of inpatients were involved in occurred at night. Only 17% of motor vehicle occupants were wearing seatbelts. In 8 of the motor vehicle crashes, the driver was allegedly under the influence of alcohol, two admitted to the vehicle being overloaded, one driver was unlicensed, twelve were allegedly driving over the speed limit and thirteen were driving on wet roads. Of the pedestrians, thirteen were crossing the road – seven of them at official pedestrian crossings. Eleven were walking on the side of the road. Minibus taxis were disproportionally involved in pedestrian–vehicle crashes, and open 'flatbed' vehicles were involved in motor vehicle occupant crashes in 20% of cases.

Our study of inpatients is relatively small, but aside from suggesting the need for further research into locally relevant risk factors on a larger scale, our results already indicate areas where intervention is needed. Vehicles should be equipped with seatbelts and their use made an enforced requirement. Routine alcohol-breath tests should become more commonplace. Speed limits should be enforced with speed cameras and spot checks day and night. Cameras at traffic signals and pedestrian crossings could be used to reduce the likelihood of pedestrian–vehicle crashes. Raised sidewalks and barriers at the side of the road should be installed to protect vulnerable road users.

KwaZulu-Natal had at one time led the way for road safety in South Africa. It initiated a project in conjunction with key road safety strategists from the state of Victoria, Australia – a state recognised as a world leader in road safety. The project (‘Asiphephe’) was initially successful, but after three years the number of RTC fatalities in KwaZulu-Natal started to increase again. Since then, provincial and national governments have led road safety initiatives in KwaZulu-Natal. Despite these, KwaZulu-Natal has consistently been the worst performing province in terms of achieving nationally set targets for a reduction in road traffic fatalities.(3,5)

An external review of Asiphephe in 2003 found many flaws in the project, but in particular the focus on education and public awareness with little reference to traffic law enforcement, road engineering and evaluation. The conclusion of the external review was that even successful foreign strategies cannot expect to be effective without significant review and adaptation based on local conditions.(26)

Based on the consistent failure of multiple strategies over a number of decades to reduce the number of RTC fatalities in KwaZulu-Natal, it could be assumed that these local conditions have not been effectively evaluated and targeted. The new international approach, replacing the focus on public education with a more holistic approach doesn’t appear to have been adopted in KwaZulu-Natal. The data we have collected should point towards more locally relevant risk factors for RTCs, and be the starting point for more research in order to develop evidence-based strategies for road safety in KwaZulu-Natal.

Road traffic crashes in South Africa: The burden of injury to a regional trauma centre

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Background. Globally, 90% of road traffic crash (RTC) deaths occur in low- and middle-income countries.
Objective. To document the mortality and morbidity associated with RTCs managed at a busy regional hospital in South Africa and investigate potentially preventable factors associated with RTCs.
Methods. This was a prospective study of all patients presenting to Edendale Hospital following a RTC over a 10-week period from late 2011 to early 2012. All fatalities recorded at the police mortuary for the same period were included. Medical records were reviewed and all admitted patients were interviewed about the circumstances of the accident. We calculated an injury pyramid to compare our data with European data.
Results. A total of 305 patients were seen over the study period, 100 required admission and there were 45 deaths due to RTCs in the area. Of the patients admitted, 41 were pedestrians involved in pedestrian vehicle crashes (PVCs) and 59 motor vehicle occupants involved in motor vehicle crashes (MVCs). The majority (n=58) of crashes involved a private vehicle. Only 17% of MVC patients were wearing a seatbelt and 8 were allegedly under the influence of alcohol. On average, RTC patients spent 19 days in hospital and 62 patients required at least 1 operation. According to our injury pyramid, the number of severe and fatal injuries was higher than in Europe.
Conclusion. Our results demonstrate a high incidence of RTCs associated with a high injury score and significant morbidity. Most crashes were associated with a number of high-risk behaviours.

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Road traffic crashes (RTCs) are a significant cause of morbidity and mortality globally and in Africa[1] – it is estimated that globally over 1.2 million people die and up to 50 million are injured each year. However, the disease burden is disproportionally distributed, with 90% of deaths and morbidities occurring in low- and middle-income countries where less than half of the world's motor vehicles are owned. As a result of urbanisation and increasing vehicle ownership in developing countries, the magnitude of the problem is set to rise. The World Health Organization (WHO) estimates that by 2020 RTCs will have risen from the 9th to the 5th leading cause of death worldwide. This will place it higher on the list of causes of death than infectious and chronic diseases.[2] South African (SA) traffic statistics show a steadily increasing number of registered vehicles and drivers[3] – with an estimated 13 802 deaths from RTCs in 2011. This is an incidence of 27.5 RTC related deaths per 100 000 population,[3] almost triple that of the USA (10.4/100 000).[4] Our study reviews the burden of RTCs borne by a busy regional hospital in SA.

Methods

We conducted a prospective study at Edendale Hospital (EH) in Pietermaritzburg over a 10-week period from late 2011 until early 2012. EH is part of a metropolitan complex that includes a tertiary hospital and a district hospital. The complex provides specialised surgical services to approximately 3 million people in the western part of KwaZulu-Natal (KZN) Province.

All patients who were seen at EH after a RTC were included in this study. Details for those discharged within 24 hours were taken from outpatient records. Patients who were formally admitted to the wards were interviewed, and their clinical notes reviewed. Once 100 consecutive inpatients had been accrued, the study was closed. A structured interview sheet was used for consistency. All patients who were interviewed gave informed consent. Information sought included: the estimated speed at which the vehicle was travelling, the use of seat belts, the abuse of substances and alcohol, and general information about the nature of the accident. Each of the admitted patients was reviewed clinically by the primary author and followed up for the purposes of the study every 48 hours until discharge. Injury severity scores (ISS) were calculated for all the admitted patients. Data concerning all fatalities from RTCs were sourced for the 10-week period under review from the police mortuary in Pietermaritzburg.

Class approval for collection of data relating to trauma patients was given by the Biomedical Research Ethics Committee, University of KZN (ref. no. BE207/09).

Results

Of the 305 patients seen over the 10-week period, 100 patients were admitted and 45 fatalities from RTCs were recorded at the police mortuary over the same time period. These included 15 from the scene of the accident, 17 from EH (of whom 4 had been admitted), and 13 from the other two hospitals in the metropolitan complex – the latter were excluded from our study. Thus, 320 RTC patients were included, with an on-scene mortality rate of 5% (15/320) and an overall mortality rate of 10% (32/320). This translates into 5 RTC patients per day and a fatality every second day. Of the 100 patients admitted, 13 were <15 years, and 67 were between 15 - 44 years. Fifty-nine patients were involved in crashes as motor vehicle occupants (MVCs) and 41 as pedestrians (PVCs). The PVC patients were, on average, younger than the MVC patients (p=0.02). The majority of crash patients were male (66%). Table 1 summarises these demographic details.

Accident details

Twenty-five crashes occurred at night and 67 during daylight hours (time of day was not known in 8 cases). There was an equal distribution of PVCs and MVCs. Thirteen pedestrians were crossing the road at the time of the accident, 7 at official pedestrian crossings, and 11 were walking on the side of the road. Of the MVCs, 14 motor vehicle occupants were drivers and 44 were passengers (1 unknown). Only 17% of motor vehicle occupants indicated that they were wearing seatbelts at the time of the accident. In 8 MVCs, the driver was allegedly under the influence of alcohol, 2 admitted to the vehicle being overloaded, 1 driver was unlicensed, 12 were allegedly driving over the speed limit and 13 were driving on wet roads. The majority of the vehicles involved were private motor vehicles, which significantly exceeded the number of commercially operated minibus taxis (Fig. 1). Of note was the high incidence of crashes associated with transporting passengers in the back of an open flatbed truck (*bakkie*).

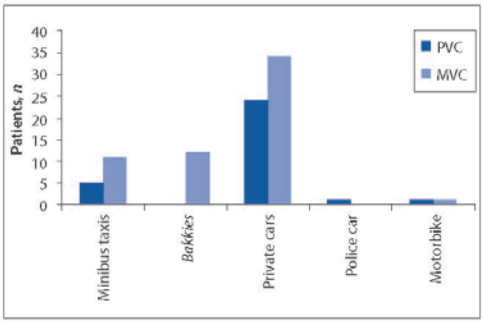

Fig. 1. Vehicles involved in road traffic crashes.

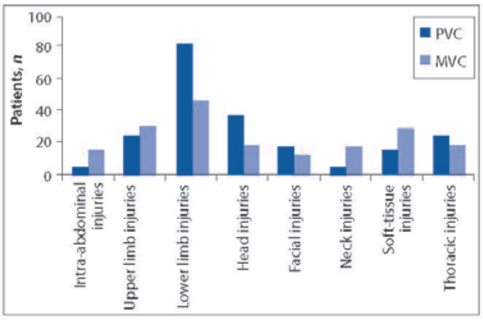

Fig. 2. Distribution of injuries according to body region.

Table 1. Patient demographics

	MVC	PVC	Total
Age (years), mean (range)	34.1 (8 - 73)	26.5 (3 - 61)	31.0 (3 - 73)
Male:female ratio	39:20	27:14	66:34

MVC = motor vehicle crashes; PVC = pedestrian vehicle crash.

Table 2. Hospital stay

	Total days, n (days per patient, mean)			
	MVC	PVC	Total	p-value
Wards	1 239 (21)	516 (12.6)	1 755	0.048
High care	22 (0.4)	11 (0.3)	33	0.72
Intensive care	31 (0.5)	40 (1.0)	71	0.36
Total, N	1 292 (22)	567 (13.8)	1 859 (18.6)	0.05

MVC = motor vehicle crash; PVC = pedestrian vehicle crash.

Spectrum of injuries

Of the 197 injuries sustained by the 100 patients, 26 patients had ≥3 injuries. There was no significant difference between PVCs and MVCs in the number of injuries sustained or the ISS (n=13.63 and n=12.37, respectively; p=0.5). The most commonly injured body region was the lower limb, followed by the upper limb (Fig. 2). Surgery was required for 62/100 patients and 90 operations were performed (182 hours of total theatre time) with 15 pedestrians and 17 motor vehicle occupants requiring ≥2 operations.

Hospital stay and outcome

The overall mortality for all RTC patients seen at EH was 5% (17/305), with the mortality for inpatients being 4% (4/100). Injured motor vehicle occupants spent significantly longer times in hospital (Table 2). The cause of death as documented by the police mortuary of patients from EH and from the scene is shown in Fig. 3. The outcomes of the admitted patients are shown in Fig. 4. Students (n=24) lost an average of 16 days of study and employed patients (n=30) lost an average of 22 days of work due to hospitalisation.

Injury pyramid

Patients were grouped according to injury: minor (not requiring hospital admission), moderate (ISS <15), severe (ISS ≥15) and fatal. This was compared with the European Commission Injury Pyramid for the European Union (2010)[5] – that for every road traffic fatality there would be 4 patients with severe injuries, 8 patients with moderate injures and 50 patients with minor injuries. The European estimates for the number of more severe injuries were adjusted according to the 192 minor injuries seen in our study (Fig. 5).

Discussion

Our study has shown that there is a high burden of injury associated with RTCs at EH. Extrapolating our data suggests that we should expect 1 664 patients per year, with 520 requiring admission and an estimated 166 deaths. This equates to 5 RTC patients per day and a fatality every second day. This constitutes a significant workload as the majority of patients required at least 1 operation and spent, on average, 3 weeks in hospital. The major burden of this operative load falls on the orthopaedic service. However, the acute general surgical and critical care services also face a significant burden. The economic burden of these crashes to society is difficult to calculate. We have shown that the majority of our patients were male (66%) and of an economically productive age (67%). The estimated loss of income is significant, with the average loss of workdays due to hospitalisation only being 3 weeks. Students involved in RTCs lost >2 weeks of schooling.

The injury pyramid created with this data clearly demonstrates the magnitude and severity of the problem of RTCs in our area, especially

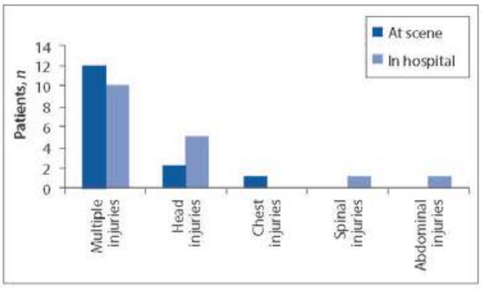

Fig. 3. Mortuary reported cause of death.

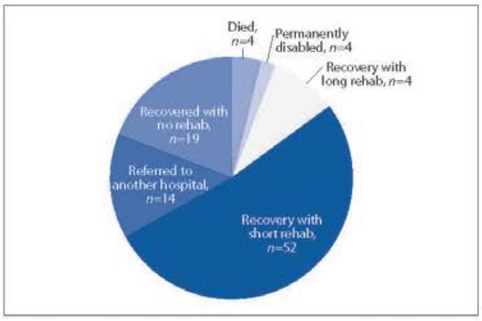

Fig. 4. Outcome of hospitalised patients. Long rehabilitation (rehab) considered as >6 weeks and short rehab as <6 weeks.

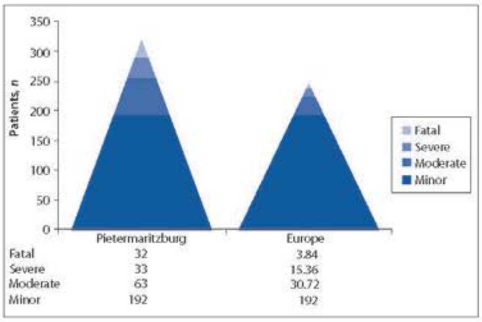

Fig. 5. Injury pyramid of morbidity and mortality v. European estimates.[5]

when compared with data from Europe.[5] With 192 minor injuries seen in a European country, approximately 31 moderate, 15 severe and 4 fatal injuries would be expected. With the same number of minor injuries seen at our hospital we saw 63 moderate, 33 severe and 32 fatal injuries. This suggests that we are seeing far more severe and fatal injuries than in the developed world.

There are 3 factors involved in RTCs – human, environmental and vehicle. Problems in each of these areas explain the differences between crashes in the developed and developing world. Human factors are thought to be the predominant causative factor in RTCs in SA (83%) compared with vehicle (9%) and environmental (8%) factors.[6] Our study supports this contention by highlighting a substantial but almost certainly an under-reported incidence of modifiable high-risk behaviour. These high-risk behaviours included speeding (20%), alcohol intoxication (14%), failure to wear seatbelts (17%) and overloading of vehicles (3%). These high-risk behaviours can be modified and it is here that public health programmes need to target their interventions. Effecting behaviour change is difficult, however, and would need to combine an educational programme with punitive legislation designed to enforce compliance with safer road use practices. This legislation also needs to be enforced adequately.

There are unique environmental factors in SA that make crashes more likely. These include rapid urbanisation against a historical background of legislated inequality. This has led to the development of poorly designed and implemented high-density human settlements with inadequate segregation of people and vehicles. The high number of pedestrian patients of RTCs in our study is typical of developing countries and highlights this problem.[4,5,8,9] Of the 41 pedestrian patients, 13 pedestrians were crossing the road (7 at official crossings) and 11 were walking on the side of the road. Informal unplanned housing developments mean communities live in close proximity to roads with no safe crossings or pavements.[7,10]

Many low-income travellers make use of private minibus taxi services rather than formal municipal bus services or trains as their routine transportation. Studies have shown an increased number of fatalities per crash in SA and other developing countries due to collisions involving vehicles with many passengers, such as buses and *bakkies*.[6,11] Without the relevant mortality data, we could not demonstrate this but of the admitted patients 27 had been in an accident involving a minibus or *bakkie*. A study of road vehicles in Gauteng demonstrated that vehicles in SA are commonly not maintained to current safety standards.[12] We can postulate that the widespread use of poorly maintained and serviced, older, second-hand vehicles contributes to the excessive incidence of RTCs in our environment.

Conclusion

Our study demonstrates the significant injury burden associated with RTC patients treated at a regional hospital in SA and confirms that the patients are often economically active and that there is a significant loss of economic activity associated with RTCs. We have highlighted the high mortality rate associated with these injuries and demonstrated that there are major modifiable risk factors that contribute to the excessive rate of RTCs. This must be regarded as a major public health problem and the approach must include research at a local and regional level aimed at directing primary prevention strategies to locally relevant risk factors.

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CHAPTER THREE: PATTERNS OF INJURIES SUSTAINED IN ROAD TRAFFIC CRASHES

Parkinson F, Kent S, Aldous C, Oosthuizen G, Clarke D. Patterns of injury seen in road crash victims in a South African trauma centre. S Afr J Surg 2013;51(4). DOI 10.7196/SAJS.1627

There were a number of interesting findings when the patterns of traumatic injury sustained in RTCs were analysed. Firstly, though the overall mortality rate from RTCs in this study was high (10%), the mortality rate for patients who reached hospital was lower than in reported series from developed countries.(18,20) The majority (76%) of these inpatient deaths occurred during the initial resuscitation. The multiplicity of injuries sustained by patients who reached hospital was also lower than those in international studies (37% vs 80–82%).(18,19) The likely explanation for these findings is that those patients with more severe, or multiple, injuries die on scene and do not reach hospital. We found that in our cohort the average length of time between the time of the crash and arrival to hospital was 9.2 hours (range 1–17 hours). This delay introduces a basic, ruthless triage system and inevitably contributes to an unacceptable on-scene death rate, not seen in developed countries with efficient pre-hospital healthcare systems.

The minority of inpatient deaths that didn't occur at initial resuscitation can be related to systemic sepsis and multi-organ failure. This has been described before.(6) In order to prevent these deaths, adequate intensive-care facilities and neurological rehabilitation facilities are required.

Another pattern that emerged was that the incidence of head injuries increased with decreasing age. This has been shown before(18) and is thought to be due to children's shorter stature leading to a higher risk of impact between the head and the vehicle, the increased surface area of the head relative to the rest of the body leading to increased chance of head injury, and the smaller volume of cerebrum leading to increased shearing forces within the cranium upon impact.

The mechanism of injury, i.e. pedestrian vs vehicle (pedestrian–vehicle crash (PVC)), or motor vehicle occupant (motor vehicle crash (MVC)), had an effect on the severity of injury seen. More PVCs than MVCs were admitted, rather than being seen and discharged from A&E. The median Injury Severity Score for admitted PVCs was 12, for MVCs it was 9 (p=0.45). Injured pedestrian patients spend significantly longer on the wards and in hospital overall.

The high incidence of pedestrian–vehicle crashes in developing countries has received much global attention.[(1,24,29)] In these countries pedestrians are often particularly vulnerable due to the lack of protected sidewalks and road crossings. The increased severity of PVCs (compared to MVCs) has also been previously described, in Africa [(12,25)] and abroad[(23)].

The mechanism of injury seen in our cohort of pedestrian patients, and previously described in other studies,[(18,19,20,21,22)] explains the pattern and severity of injuries seen in PVCs. Pedestrians in our group predominantly sustained lower-extremity injuries, head and torso injuries and upper-limb fractures. This is because these victims sustain three impacts: 1) impact with the vehicle bumper, 2) impact with the hood and windscreen, 3) impact with the ground. This translates into: 1) lower-limb injuries, 2) head and torso injuries, 3) head and ‘outstretched’ upper-limb injuries.

The pattern of injuries seen in motor vehicle occupants has not been as well described. This may be because a ‘pattern’ is less well recognised due to the difference in types of vehicle, and variation in safety features. An occupant in a vehicle with seatbelts and airbags will have significantly different injuries to a person sitting in the back of an open flatbed truck. In our cohort there was a high incidence of crashes associated with these trucks. In our series, motor vehicle occupants often sustained neck, abdominal and upper-arm injuries. Neck injuries could be due to rapid deceleration, particularly as only 17% of this cohort were wearing seatbelts. Abdominal injuries could be due to impact against the steering wheel, dashboard or side of the truck. Caving in of the side of the car or truck, or ejection from the vehicle, could result in upper-arm injuries.

Interestingly the cost of the patient's inpatient stay could be logically explained by the particular injury sustained. Upper-limb injuries incurred significant cost from long operations. These injuries commonly involved soft tissue, bone and vascular injuries, therefore requiring several long, multidisciplinary operations. Their increased cost is also due to the use of prosthetic orthopaedic implants. Pelvic injuries were also costly due to the use of prosthetic implants. However the major cost driver in pelvic trauma is the prolonged hospital stay for bed rest and traction. The expense with cervical-spine injury was driven by the need for advanced radiological imaging. Orthopaedic implants drove up the cost of lower-limb injuries. The expense for blunt thoracic trauma is the length of stay in ICU. These patients typically sustain pulmonary contusions and require prolonged respiratory support. Head injuries typically have multiple CT scans and lengthy rehabilitation.

The knowledge regarding the severity and pattern of injuries sustained in RTCs should enable doctors to anticipate and efficiently manage these patients from the moment they are referred, or once they arrive at hospital. This is particularly useful in rural South Africa where the patient may well have already been delayed because of inadequate pre-hospital services.

Patterns of injury can be used in conjunction with research into patterns of road use and risk factors in order to develop road safety strategies. Knowledge of the costs of various drivers associated with each injury should act as a stimulus for the development of such strategies, and could also be used by local healthcare providers to target potential efficiency savings.

Patterns of injury seen in road crash victims in a South African trauma centre

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Background. Road traffic crashes (RTCs) account for a significant burden of disease in South Africa. This prospective study reviews basic demographic and outcome data of patients who sustained an RTC-related injury and analyses the common patterns of injury associated with specific mechanisms of injury.
Method. We reviewed all patients seen at a single regional hospital (Edendale Hospital, Pietermaritzburg) with injuries sustained in RTCs over a 10-week period. State mortuary data were gathered on all RTC-related fatalities over the same period.
Results. Three hundred and five RTC patients were seen at the hospital over the 10-week period. The average transfer time to hospital was 9.2 hours (range 1 - 17 hours). One hundred patients were admitted and the rest were discharged home from the emergency department. Of the admitted cohort, 59 were motor vehicle occupants (MVC group) and 41 were pedestrians (PVC group). PVC patients commonly had lower limb, head, radio-ulnar and clavicular injuries, while MVC patients commonly had neck and intra-abdominal injuries. Thirty-seven patients had multiple injuries. The in-hospital mortality rate was 5.6%, but the overall mortality rate was 10.0%, as 15 patients died at the scene.
Conclusions. Patterns of injury differ according to the mechanism of injury. Pedestrians impact against various parts of the vehicle and the ground and so sustain injuries to their arms and legs. Occupants of vehicles impact against the dashboard and steering wheel and are more likely to sustain torso injuries. The low number of severe injuries and multiple injuries and the relatively low inpatient mortality rate are a consequence of the triage effect of long delays in transfer. More severely injured patients are more likely to die at the scene.

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South Africa has a major burden of injury related to road traffic crashes (RTCs). The widespread use of flat-bed trucks and overcrowded minibuses to transport passengers and a pervasive culture of disregard for the rules of the road result in a very high rate of RTCs. This situation is not confined to South Africa but appears to be widespread throughout the developing world, and RTCs are a significant cause of morbidity and mortality globally. It is estimated that over 1.2 million people die and up to 50 million are injured each year worldwide as a result of RTCs. However, the burden of these injuries is disproportionally distributed, with 90% of these deaths and morbidities occurring in middle- and low-income countries, where less than half of the world's motor vehicles are owned.[1] As a result of urbanisation and increased vehicle ownership in developing countries, the magnitude of the problem is likely to rise. The World Health Organization estimates that by the end of the current decade RTCs will have risen from the 9th to the 5th leading cause of death worldwide.[1] The situation in South Africa supports this prediction, as South African traffic statistics have demonstrated a steadily increasing number of registered vehicles and drivers and there were 13 802 deaths from RTCs in South Africa during 2011.[2]

This prospective study reviewed all trauma admissions subsequent to an RTC at a single busy regional hospital and attempted to determine the common mechanisms of injury and associated patterns of injury.

Methods

The Metropolitan Trauma Service in Pietermaritzburg, KwaZulu-Natal, has class approval from the relevant ethics review boards to maintain a prospective database on all trauma patients under its care. This study was undertaken at Edendale Hospital, a busy regional hospital in Pietermaritzburg. It is the regional referral hospital for approximately 3 million people in Pietermaritzburg, as well as the deep rural areas of Sinsonke Health District. The load of referrals is shared with the tertiary hospital based in the same city. Data were taken from a 10-week period from late 2011 to early 2012. Details for those discharged from the emergency department (ED) were taken from the outpatient records. The clinical notes for all admitted patients were reviewed, and structured interviews were carried out with all patients who had a Glasgow Coma Score (GCS) of 15/15 during admission. All patients who were interviewed gave informed consent to be interviewed. Patients whose GCS did not reach 15 during admission were not interviewed. Information sought included the estimated speed at which the vehicle was travelling, use of seatbelts, abuse of substances and general information about the nature of the crash. Each of the admitted patients was reviewed clinically by the primary author (FP) and followed up every 48 hours until discharge. An Injury Severity Score (ISS) was calculated for all the admitted patients. The time between the crash and arrival at the hospital was taken from ambulance sheets where possible, and data from the patient and ED records elsewhere. State mortuary data were gathered on the number of corpses taken to the police mortuary following an RTC over the same period.

Results

A total of 305 patients were seen at our hospital following an RTC over the 10-week study period. One hundred of these patients were admitted. A total of 45 deaths from RTCs were recorded at the police mortuary over the same time period. These included 15 from the scene of the crash, 17 from Edendale Hospital (of which 13 occurred during initial resuscitation and 4 after admission), and 13 from the other hospitals in the metropolitan complex. These 13 fatalities were excluded from the study. This makes a total of 320 RTC victims over a 10-week period, with an on-scene mortality rate of 4.7% (15/320) and an overall mortality rate of 10.0% (32/320), translating into 5 RTC victims every day and a fatality every second day.

The causes of death at the scene and in hospital are compared in Fig. 1. The most common cause of death in both environments was multiple injuries, followed by head injury. The time delay between the crash and arrival at hospital was recorded in one-third of the patients and was 9.2 hours on average (range 1 - 17 hours). The majority of these patients were brought to hospital by ambulance. Of the 100 patients who were admitted, 13 were aged less than 15 years and 68 between 15 and 44 years. Table 1 summarises the demographics of the admitted group. Fifty-nine patients were involved in crashes as motor vehicle occupants (MVCs) and 41 as pedestrians (PVCs). The PVC patients were on average younger than

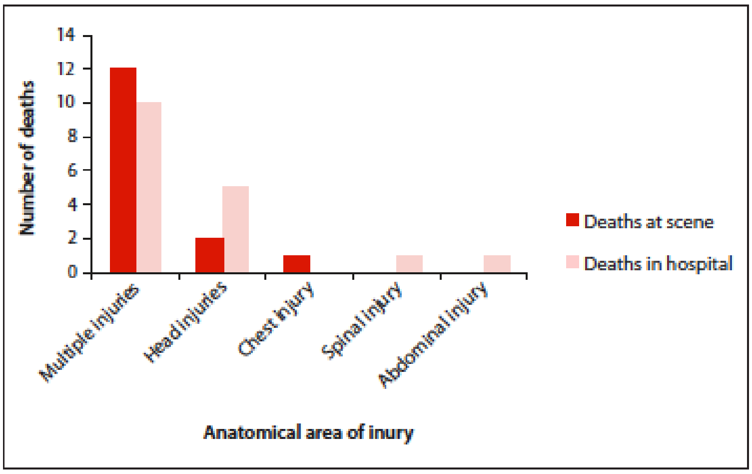

Fig. 1. Causes of death at scene and in hospital.

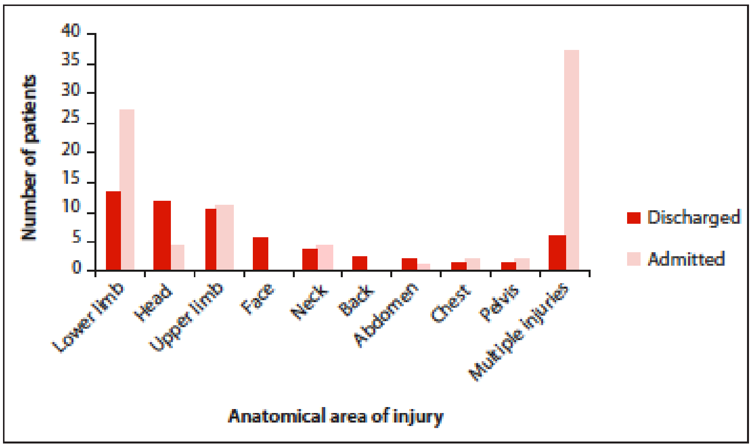

Fig. 2. Injuries in the admitted patients compared with patients discharged from the emergency department.

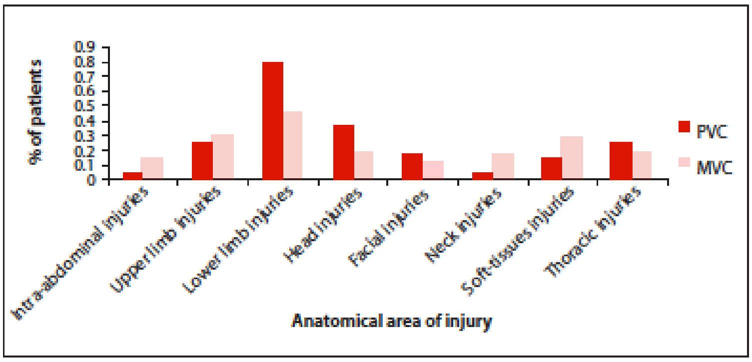

Fig. 3. Distribution of injuries in pedestrian (PVC) and motor vehicle occupant (MVC) patients.

the MVC patients (p=0.02). In the group of patients not admitted to hospital, 39 had been involved in PVCs and 166 in MVCs. Multiple injuries, defined as any injury to more than one anatomical area noted during the primary survey, were more common in the admitted patients than the discharged patients (Fig. 2): 34% of those admitted after MVCs and 44% of those admitted after PVCs (p=0.32). While a greater proportion of the PVC group was admitted (41/80 of PVCs v. 59/225 of MVCs (p<0.0001)), the admitted PVC and MVC groups were similar in terms of severity of injury (median PVC ISS 12, interquartile range (IQR) 8 - 17; median MVC ISS 9, IQR 4 - 18 (p=0.45)).

However, the pattern of injury differed markedly between the two groups (Figs 3 - 5). More PVC patients than MVC patients had lower limb (tibia-fibula), clavicle and radio-ulnar fractures, head, facial and thoracic injuries. More MVC patients had humeral, neck and intra-abdominal injuries. The incidence of head injuries decreased with age in both MVC and PVC patients.

Discussion

RTCs cause significant morbidity and mortality in the developing world. Ninety per cent of the 1.2 million deaths a year from RTCs occur in low- and middle-income countries,[1] where 81% of the world's population live and own about 20% of the world's vehicles.[3] Rapid urbanisation with inadequate city planning results in large numbers of vulnerable road users such as cyclists and pedestrians sharing the same space as vehicles. There are a number of differences between trauma in a developing country such as South Africa and the developed world. The significant delay between the time of the crash and arrival at hospital (average of 9.2 hours, range 1 - 17 hours) reflects an immature trauma system, translating into much poorer outcomes for major trauma than in developed countries. The patients in this cohort had a much lower rate of multiple injuries compared with patients in international series (37% v. 80 - 82%).[4,5] The overall mortality rate was 10%; however, the mortality rate for patients who reached hospital was lower than that reported in series from developed countries,[4,6] and the majority (76%) of the deaths in hospital occurred during initial resuscitation. The most plausible explanation for this is that more severely injured patients do not survive the prolonged transfer times documented in this study. In effect, the long transfer times act as a ruthless triage mechanism, which eliminates a certain spectrum of patients.

Causes of death differ according to geographical location. The major causes of death at the scene are multiple injuries and head injuries. This is in keeping with the well-described triphasic pattern of death seen in trauma. Deaths from abdominal injuries, spinal injuries and chest injuries tend to occur at a later phase in hospital. Head injuries in themselves are a significant cause of mortality. ISS scores did not differ significantly between MVCs and PVCs, but there was a trend for the PVC group to sustain more multiple injuries and to have a higher rate of admission.

Different patterns of injury were associated with different mechanisms of injury in our cohort. PVC patients were admitted more often than the MVC group, reflecting the seriousness of their injuries, although ISS scores for the two admitted groups were not significantly different. The admitted group were more likely to have multiple injuries and lower limb injuries than the patients who were primarily discharged from the ED. Of the admitted group, pedestrians predominantly sustained lower extremity injuries, upper limb fractures and head and torso injuries. These victims sustain three impacts: (i) the impact of the vehicle bumper; (ii) impact with the bonnet and windscreen; and (iii) impact with the ground. This translates into: (i) lower limb injuries; (ii) head and torso injuries; and (iii) head and 'outstretched'

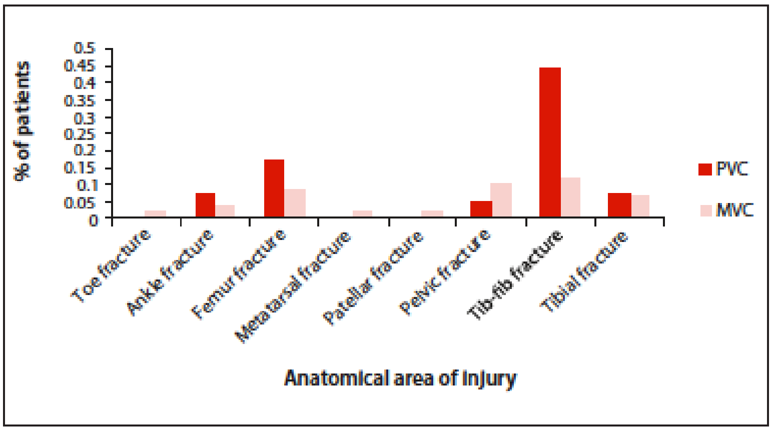

Fig. 4. Distribution of lower limb injuries in pedestrian (PVC) and motor vehicle occupant (MVC) patients.

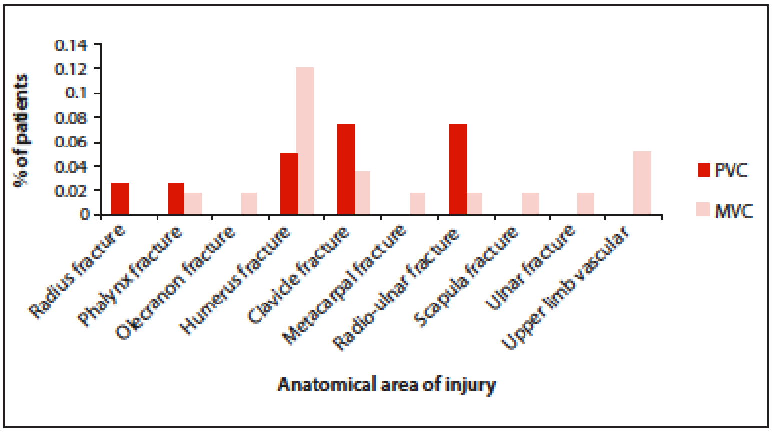

Fig. 5. Distribution of upper limb injuries in pedestrian (PVC) and motor vehicle occupant (MVC) patients.

Table 1. Demographics of patients admitted to hospital after a road traffic crash

	MVC	PVC	Total
M:F	39:20	27:14	66:34
Age (years)			
<15	4	9	13
15 - 30	26	20	46
31 - 44	16	6	22
45 - 60	8	5	13
>61	5	1	6

MVC = motor vehicle occupant; PVC = pedestrian; M = males; F = females.

upper limb injuries. Motor vehicle occupants more commonly sustained neck, abdominal and upper arm injuries. The mechanism of rapid deceleration results in neck injuries, and impact against the steering wheel or dashboard or caving in of the side of the car results in intra-abdominal and upper arm injuries.

The study was conducted over December and January, months that have been shown to have the highest and lowest number of fatal crashes, respectively,[2] so the data should reflect the general incidence of crashes throughout the year.

Conclusion

This study demonstrates problems with access to healthcare and logistics in KwaZulu-Natal, and the significant effect this has on mortality from RTCs. It also shows common patterns of injury depending on patient age and mechanism of injury. Pedestrians are more likely to sustain upper and lower limb fractures, paediatric pedestrians are more likely to sustain head injuries, and motor vehicle occupants tend to sustain blunt torso trauma.

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CHAPTER FOUR: THE COST OF INJURIES SUSTAINED IN ROAD TRAFFIC CRASHES

Parkinson F, Kent SJ, Aldous C, Oosthuizen G, Clarke D. The hospital cost of road traffic accidents at a South African regional trauma centre: A micro-costing study. Injury 2013 (Epub ahead of print) DOI 10.1016/j.injury.2013.04.007

The costs associated with loss of productivity, as well as human-value costs, constitute the greatest proportion of costs associated with RTCs. Hospital costs have been estimated to contribute between only 4% and 13% of the overall cost. [14,27] However the hospital costs associated with road traffic crashes are not well known in South Africa. To date, such costs have been estimated by top-down costing methods in two published analyses[14,15], and by micro-costing methods in another pilot study.[16] Significant variation has been shown between the results of each method.[28] Micro-costing is regarded as the 'gold standard' for costing inpatient stays because of its detailed and inclusive approach.

The micro-costing pilot study was of consumables, charged according to charging sheets and procedures developed in the private sector. The gross output studies included indirect costs (such as damaged property costs, legal costs, loss of economic output), and used the top-down method to calculate direct costs such as medical costs. The results from the government study of RTC victims using top-down methods calculated that average healthcare cost per RTC patient was $239.[14] The average cost of consumables per patient calculated by the pilot micro-costing study was $486.[16]

This research included a micro-costing study of the hospital costs incurred by each patient during their treatment for injuries sustained in an RTC. A detailed 'invoice' for each individual inpatient was calculated by reviewing the patient every 48 hours and detailing all interventions (medications, operations, minor procedures, investigations). The cost of each intervention was calculated from hospital and national price lists and the sum of all interventions totalled. The average cost of a patient's inpatient hospital stay was $6,988.

Though this cost is higher than the total published by previous studies it may still be an underestimation of the actual cost: staff salaries were not included; nor were medications and fluids given as infusions, because of the difficulty in monitoring them. Despite this, due to the otherwise exhaustive methods used, our estimates are likely to be more reliable than those previously published and should bring attention to the financial burden of road traffic collisions in our area.

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No generic formulae were used in keeping with the bottom up methodology of this study.

The price of radiological procedures was taken from the South African Board of Healthcare Funder's National Health Reference Price list. The price of blood transfusions, laboratory tests and drugs were calculated directly from our hospital's blood bank, laboratory and pharmacy pricing lists. The price of ward adjuncts such as nasogastric (NG) tubes, urinary catheters, chest drains etc., was calculated using the hospital's stock pricelist. The price of NG feeds and total parental nutrition (TPN) was taken from the dietetic department's pricelist. If the patient had had any operations the length of time spent in theatre was obtained from theatre records. The price of theatre overheads such as lighting and heating per minute in theatre had been previously calculated in another published study performed in our hospital.[4] In addition to this cost an average cost of surgical sundries was added to each case and for orthopaedic cases the cost of any implants used was taken from the patient's individual invoice. Each individual patient's hospital stay (including length of stay in the intensive care unit and high care unit) was known, and the hospital overhead cost per day was obtained from the hospital Finance Manager. The ward overhead cost was the cost of providing the environment in which the patient was cared for (heating, electricity, water) but did not include staff salaries. It was not possible to monitor the extent of staff involvement in each patient's care therefore the cost of staff salaries was not included.

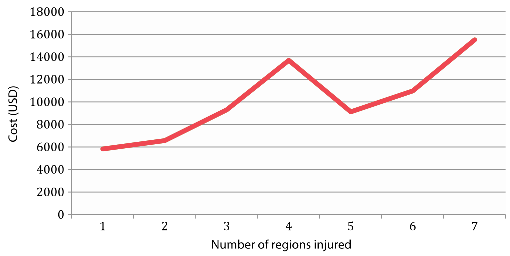
Student *t*-test was used to determine significance. Significance was inferred at $p < 0.05$.

Results

One hundred patients were admitted following a RTC over the ten weeks of the study. Forty-one were pedestrians (PVCs) and 59 were motor vehicle occupants (MVCs). Sixty-seven patients were between the ages of 15–44 years. On average patients spent 19 days in hospital. Table 1 summarises the patient demographics and the basic clinical details of the two groups. A total of 197 injuries were sustained by the one hundred patients. Twenty-six patients had three or more injuries. There was no significant difference between MVCs and PVCs in the number of injuries sustained or the Injury Severity Score (median ISS (interquartile range) PVCs 12 (8:17); MVCs 9 (4:18), $p = 0.45$). The most commonly injured body region was the lower limb followed by the upper limb. Sixty-two of the 100 patients required surgery. Ninety operations were performed in total (182 h of operating time). Fifteen pedestrians and seventeen motor vehicle occupants required two or more operations. Forty-eight patients required at least one orthopaedic implant. The total cost of in-patient hospital care for victims of RTCs admitted over the ten week period was $6,98,850. The average cost of care for a pedestrian victim of an RTC was $6789 and for an occupant of a vehicle involved in an RTC was $7127 ($p > 0.5$) (Table 2). The cost according to body region injured was calculated for the patients who only injured one body region (Table 3). Then the average cost was plotted against the number of body regions injured and showed that as the number of injuries increased so the total cost increased exponentially. Fig. 1 demonstrates this relationship.

Table 2
Average cost per individual cost driver and total cost (USD converted from ZAR at rates current at time of the study).

	PVC (41) Average/patient	MVC (59) Average/patient	Total
Days on ward	2152	3279	281,681
Days in ICU/HDU	534	385	44,616
Ward sundries	15	11	1276
NG feeds	10	6	733
Medication	50	52	5122
Radiology	625	619	62,146
Lab tests	99	79	8756
Blood transfusions	208	121	15,660
Time in Operating theatre (OT)	1373	1558	148,230
OT sundries	43	40	4143
Implants	1680	977	126,487
Total	6789	7127	698,850



Discussion

There are two methods of calculating direct costs, the micro (bottom-up) and gross (top-down) approaches. Micro-costing involves recording and costing each component of a patient's care and summing them to obtain a total cost per patient. Gross costing takes the overall institutional cost and divides it by the number of patients treated to generate an average cost per patient. Due to the level of detail involved the micro-costing approach is regarded as the 'gold standard' for costing inpatient stays. However, it is labour intensive and impractical for use on a large scale. Studies have shown significant variation between the methods.[5] A local study costed orthopaedic trauma at a regional hospital using both approaches and demonstrated a difference of up to 20% between the two methods.[6] There are two major published costing analyses of road traffic crashes in South Africa.

Table 1
Patient demographics.

	MVCs ($N = 59$)	PVCs ($N = 41$)	*P* value	Total
Mean age (median, range)	34.1 (30, 8–73)	26.5 (23, 3–61)		31.0 (28, 3–73)
Male:Female	39:20	27:14		66:34
Days on the wards (total, mean)	1239 (20.6)	516 (12.6)	0.048	1755
Days in High care (total, mean)	22 (0.4)	11 (0.3)	0.72	33
Days in intensive care (total, mean)	31 (0.5)	40 (1.0)	0.36	71
Total days in hospital (total, mean)	1292 (21.5)	567 (13.8)	0.05	1859 (18.6)

l trauma centre:
A micro-costing study. Injury (2013), http://dx.doi.org/10.1016/j.injury.2013.04.007

Table 3
Average cost per patient according body region injured (in USD).

	Upper limb (11)	Pelvis (2)	Neck (4)	Lower limb (27)	Abdomen (1)	Thorax (2)	Head (5)	Soft tissue (11)
Days on ward	4626	6225	7003	2185	1868	467	1587	566
Days in ICU/HDU	39	0	0	0	0	1716	257	0
Ward sundries	8	2	16	4	9	56	6	8
NG feeds	0	0	0	0	0	0	9	0
Medication	52	40	47	19	139	44	29	10
Radiology	336	423	985	201	841	365	872	239
Lab tests	60	28	31	32	222	186	57	24
Blood transfusions	126	461	0	43	230	0	0	209
Time in OT	3535	1418	0	1365	1215	0	0	295
OT sundries	88	29	0	54	29	0	0	5
Implants	1741	819	0	2034	0	0	0	0
Total	10,610	9444	8082	5935	4553	2834	2817	1356

Both use top down costing methods.[7,8] There is a well conducted bottom up micro-costing study of the cost of gunshot victims, and a single pilot micro-costing study of motor vehicle crash victims presenting to a Johannesburg hospital using data from fourteen patients.[9,10] The pilot study was of consumables, charged according to charging sheets and procedures developed in the private sector. The gross output studies included indirect costs (such as damaged property costs, legal costs, loss of economic output), and used the top-down method to calculate direct costs such as medical costs. The results from the government study of RTC victims using top-down methods calculated that average healthcare cost per RTC patient was $239.[7] The average cost of consumables per patient calculated by the pilot micro-costing study was $486. The average cost per patient using our micro-costing methods was $6988. The exhaustive micro-costing used in this study included all the components of the patient's care and is hence more likely to be a true reflection of the cost that either the two top down studies or the small pilot study.

Despite the longer hospital stay the cost for pedestrian victims or passengers and drivers was similar. When analysing the cost of injury to individual body parts a number of patterns emerge. Upper limb injuries incurred significant cost from long operations. These injuries commonly involved soft tissue, bone and vascular injuries, therefore requiring several long, multidisciplinary operations. Their increased cost is also due to the use of prosthetic implants. Pelvic injuries were also costly due to the use of prosthetic implants. However the major cost driver in pelvic trauma is the prolonged hospital stay for bed rest and traction. The expense with cervical spine injury was driven by the need for advanced radiological imaging. Orthopaedic implants drove the cost of lower limb injuries up. The expense for blunt thoracic trauma is the length of stay in ICU. These patients typically sustain pulmonary contusions and require prolonged respiratory support. Head injuries typically have multiple CT scans and lengthy rehabilitation. Knowing the cost drivers for specific injuries may help with future costing studies and with quality improvement programmes aimed at both containing costs and improving outcomes.

Direct healthcare costs can be divided into fixed and variable costs. Variable costs include medication, radiological investigations and theatre time – costs that doctors and nurses can influence. These were included in our analysis. Fixed costs include the cost of hospital buildings and maintenance. We included staff salaries as fixed costs and they were excluded from our analysis. Due to difficulty in monitoring consumption, drugs given as infusions (such as fluids and drugs in intensive care) were not included in this analysis. For the same reason dressings were not included. The cost of ward adjuncts (such as venous and urinary catheters) was calculated but is likely to be an underestimation as they were difficult to monitor. Our study did not consider indirect costs such as lost productivity and human value costs – which are generally far greater than the direct costs of injuries.[11] In a study looking at firearm injuries direct medical cost was estimated to contribute only 13% of the overall cost.[12] Another South African study estimated that hospital costs constituted less than 4% of the total cost of a crash to the patient and economy.[7] Therefore the total costs calculated are likely to be an underestimation of the actual cost. This local micro-costing needs to be repeated as part of a multi-centre study to confirm the average costs of RTCs per patient and per injured body parts. This would allow planners to develop current national cost estimates, which could be used to make large nation wide top down studies of cost more accurate.

Conclusion

The direct cost to the health system of road traffic crashes is considerable. This places a significant financial burden on any hospital treating large volumes of trauma patients. The major costs associated with the care of RTC victims must be taken into consideration when allocating hospital budgets. The figures we have generated with this study may be useful in larger population based costings of road traffic crashes. Data generated from such work may be useful in demonstrating the cost effectiveness of more aggressive injury prevention programmes.

Conflict of interest statement

None declared.

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CHAPTER FIVE: LIMITATIONS, FUTURE RESEARCH AND CONCLUSION

Limitations

Edendale Hospital has a catchment area including rural and urban habitations. It is a tertiary referral centre for trauma. The caseload seen at Edendale Hospital will be typical of hospitals of its size in KwaZulu-Natal, but results may have been different if RTC admissions to more local hospitals had been studied (more minor injuries may have been seen, and the transfer time may have been shorter).

KwaZulu-Natal is one of the worst performing provinces for road safety in South Africa. Therefore it cannot be assumed that our findings would be replicated in the better performing provinces in South Africa.

The costing methods used in this study were thorough. However some costs were excluded: fluids and medication given as infusions were not counted because of difficulty in keeping track of the amount infused. Dressings were not included for the same reason. The cost of ward adjuncts (such as venous and urinary catheters) was included, but is likely to be an underestimation of the actual cost as use of these adjuncts may not always have been recorded in the medical notes. We excluded fixed costs such as cost of hospital building maintenance and staff salaries. This study didn't examine the indirect costs of injury such as lost productivity and human-value costs – these are generally far greater than the direct costs of injuries.

Two possible outcomes for patients were 'short rehabilitation' and 'long rehabilitation', with a cut-off of six weeks. The patients were not followed up after discharge, and so this was a subjective, clinical assessment made by the primary researcher upon discharge. The outcomes may have varied from these predictions.

Another subjective element of the study was regarding risk factors: the patient was asked whether the driver was under the influence of alcohol, speeding, or whether the road was wet or the vehicle overloaded. This data is therefore unvalidated. Only 17% of motor vehicle occupants claimed to have been wearing seatbelts – this figure is unexpectedly low, which indicates it may be a reasonably accurate reflection of the true figure.

Data was collected prospectively for hospital admissions, but police mortuary records were reviewed retrospectively. There was limited data available on these fatalities; more may have been available had the data been collected prospectively.

This study was relatively small, and power calculations were not performed prior to the study. Therefore few of our findings had statistical significance.

Implications for future research

This study has confirmed previous global and African findings regarding the incidence and severity of RTCs in developing countries. It has generated new local knowledge particular to the area surrounding Edendale: there are a high number of RTCs, pedestrians in particular sustain severe injuries, children tend to be involved in RTCs as pedestrians, and the injuries caused by RTCs require intensive hospital treatment. To further the epidemiological aspect of the study it would be useful to carry out similar studies in local hospitals to capture data on those patients who are not referred to the tertiary trauma centre.

Information regarding risk factors such as speeding, alcohol use and seatbelt use was gathered by interview with the patient. Further research could be done with collaboration between hospital and police researchers examining police records of each incident in order to objectively evaluate risk factors for crashes. With this information a more causal link between various risk factors and injuries sustained could be determined.

The data identified a significant problem with pre-hospital care for these trauma patients. Transfer time was lengthy. There is scope for development of a first-responder service. Our results should first be validated by a study of how emergency services are being contacted, how long they take to arrive at the scene, how long they spend at the scene and what procedures are being performed before, and while, the patient is transferred. Accurate data regarding the time of death, with reference to the time of the accident, call for help and arrival of the paramedics needs to be gathered and the pre-hospital service reviewed in light of this.

A costing study using micro-costing methods had not previously been carried out in South Africa for any kind of trauma, nor had a study of this magnitude. The costs varied greatly from the costs published in a government report that used less accurate costing methods. Owing to the exhaustive methods involved in micro-costing this study could not be repeated on a larger scale. However the methods could be copied in order to study the direct costs of other traumatic injuries (firearm, domestic violence) or at another hospital, in order to validate the method and derive further information on the cost of trauma to government hospitals.

The hospital costs of these injuries, along with the data on morbidity and mortality, should be stimulus enough to encourage government spending to reduce the risk of RTCs in KwaZulu-Natal. However in order to be most cost-effective, economic studies of various interventions should be conducted. Some work has been published regarding this: Chisholm et al looked at the cost-effectiveness for sub-Saharan Africa and Asia of legislation and enforcement of speed limits, drink-driving limits, use of seatbelts, and helmet use by motorcyclists and bicyclists, as well as the effectiveness of combinations of interventions.(21) They demonstrated that the effectiveness of each intervention varied geographically, and though each intervention was effective, the interventions were most cost-effective when combined.

A review of interventions was performed by Hazen, and described mandatory seatbelt usage as the most effective measure for increasing the safety of motor vehicle occupants, and better road engineering (barriers and raised sidewalks) to be the best intervention for pedestrians. The most cost-effective measures were cross-cutting interventions that confer benefit to both motor vehicle occupants and other road users – such as speed limit and drink-driving limit law enforcement.(30) This study has highlighted lack of seatbelt use as a particularly prevalent problem in the Edendale catchment area.

Indirect costs, such as lost productivity and human-value costs could be researched to add to the evaluations of the cost-effectiveness of various interventions.

Conclusion

The problem that stimulated this research was the recognition of the significant workload on the health system associated with patients hospitalised with injuries sustained in road traffic crashes.

There were three aims of the study: to define the problem of road traffic crashes in terms of morbidity, mortality and cost in the locality surrounding Edendale Hospital; to derive locally relevant risk factors; and to determine common patterns of injury.

Data demonstrated a mortality rate of 10% for crashes over a 10 week period. One hundred patients were hospitalised, with an average injury severity score of 12.9. The average cost of an inpatient stay was $6,988.

Prevalent risk factors included lack of seatbelt use, and speeding. A significant number of flatbed trucks and minibuses were involved in crashes.

Pedestrian injuries were typically more severe. Delay in arrival to hospital may have contributed to the high on-scene mortality rate. A recognisable pattern of injury for pedestrians and motor vehicle occupants was identified.

Road safety strategies in KwaZulu-Natal have been largely focused on public awareness and education. Epidemiological evidence such as this suggests current strategies are not successful. Globally there has been a trend away from education and towards measures that influence behaviours, reduce human error, and reduce the effect of human error – such as law enforcement, road lighting, and safer car and road design.

This research has identified a need for current road safety strategies and pre-hospital services in KwaZulu-Natal to change. It has identified potential areas for change (seatbelt use enforcement, road barriers to protect vulnerable road users and more efficient first responders). It has provided economic stimulus for change.

Now the cost-effectiveness of local road safety interventions needs to be calculated. The pre-hospital services need to be urgently reviewed. This research has highlighted the need for a combination of targeted interventions to prevent road traffic crashes, and the provision of efficient first-responder services in order to reduce RTC-related morbidity, mortality and hospital costs in KwaZulu-Natal.

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Appendices

Appendix 1: Ethics approval

Appendix 2: The study protocol

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Spectrum and cost of road traffic accidents: Data from a regional South African Hospital

MMed Surgery

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Executive summary

This study is necessary to determine the magnitude of the problem of road traffic accidents facing healthcare facilities in Kwa-Zulu Natal – an area where fatalities from road traffic accidents are not being controlled by national measures. The study will determine the morbidity, mortality and cost associated with these accidents by collecting data from patient records and the state mortuary prospectively. This information will determine the significance of the burden on South African healthcare facilities, identify common risk factors and the cost associated with caring for victims of these accidents, in order to direct preventative measures appropriately and incentivize local decision makers into investment into road safety measures. Additionally, local knowledge regarding accident and injury patterns will inform healthcare providers, enabling them to provide more efficient and targeted care.

1. The research problem

Road traffic crashes (RTCs) are a significant global problem – over 1.2 million people die and up to 50 million people are injured every year as a result of RTCs. This morbidity and mortality is not evenly distributed – 90% of these deaths and injuries occur in low and middle income countries (1). As these countries develop, increasing urbanisation and vehicle ownership mean that the problem of RTCs is predicted to increase. In 2003 the UN determined that research is a crucial step towards improvement in road safety – particularly in developing countries where research is currently lacking (2).

Kwa-Zulu Natal has consistently been the worst performing province in terms of reducing the number of RTC associated fatalities in South Africa, yet there is no research from this area into why this is (3,4).

There are three phases where morbidity and mortality are likely to occur after a road traffic crash (5). Phase one includes immediate death or death in the period immediately after the crash. There is little that can be done to save these lives once the crash has happened, so the key to preventing deaths in this phase is preventative measures to stop road crashes from happening. There are unique risk factors for road crashes in developing countries (particularly rural areas), such as a rapid urbanisation and poor city planning leading to a greater number of pedestrians in close contact with motor vehicles, overloaded vehicles and unrestrained passengers, poorly maintained vehicles, and poor law enforcement and corruption. These need to be researched into and efforts focused on reducing risk according to local behaviours.

The second phase is the period of a few hours after the crash has occurred. This time is known as the 'golden hour', and it is here that efficient and adequate medical resuscitation of patients will make the difference between life and death. The key determinants here are pre-hospital care, access to facilities, and appropriate triage and rapid assessment of these patients. Again in developing countries, access to healthcare can be limited and research into the extent of this problem could be useful in resource planning. Knowing typical patterns of injury to expect depending on mechanism of injury will help receiving medics initiate appropriate investigations and treatment promptly.

The third phase of death is over the following days of admission, when injury complications such as sepsis may hinder survival. Trauma intensive care facilities are necessary to control this risk.

We designed this study to research into RTC-associated morbidity and mortality, particularly that occurring in phases 1 and 2 of death.

2. Literature overview and motivation

Globally there is a body of evidence demonstrating the magnitude of the problem of road safety. The World Health Organisation (WHO) has determined that road traffic crashes (RTCs) are the 9th leading cause of morbidity and mortality globally (1). The UN has expressed concern at the increase of traffic fatalities and injuries worldwide since the 1970s, and in their 2003 resolution remained convinced that RTCs are a major public health problem, requiring concerted efforts for effective and sustainable prevention (2).

Both the WHO and the United Nations (UN) have also recognized the disparity between developing and developed nations in the distribution of RTC related morbidity and mortality. In their 2009 report the WHO compared developed and developing countries in terms of law enforcement, number of registered vehicles and number of fatalities among other variables. They found high fatality rates and low levels of law enforcement in South Africa (1) and other developing countries.

Kwa-Zulu Natal has consistently been the worst performing province in terms of reducing the number of RTC associated fatalities in South Africa (3,4).

Literature review – the burden of trauma from RTCs

Muckhart had already recognized the problem of road trauma in South Africa in a seminal paper in 1990, describing trauma in South Africa as a malignant epidemic (5). His descriptive paper focused on trauma in our area of South Africa – Kwa-Zulu Natal, and even then acknowledged RTCs as an ever-growing burden on the health service. He described three phases in which mortality from RTCs occurs, and suggested that death in each phase can be prevented with appropriate research and focused improvements. He called for increased attention from the authorities and medical profession.

The Transport Research Laboratory (London, 1997) (6) reviewed the trends and socioeconomic aspects of RTCs in developing countries, and acknowledged the substantial impact they have on RTCs and the need for increased resources to be directed at their prevention.

Since, a number of descriptive papers examining the extent of the problem and unique factors affecting developing countries have also been published. In 1997 Odero reviewed epidemiological studies of RTCs in developing countries, and demonstrated the increased number of pedestrian fatalities and greater number of high-risk vehicles such as open topped lorries used for transporting passengers (7).

In 2001 Van Schoor conducted a prospective study into the contribution of mechanical failures to RTCs in South Africa, using data from accident response units and a roadside survey. They found that 40% of suburban vehicles had potential mechanical defects (8).

In 2002 Nantulya wrote a descriptive paper summarizing other reasons for the high burden of morbidity and mortality in developing countries such as increased number of vehicles and poor enforcement of regulations (9). Hazen (2006) (10) had the same approach but included the problem of drink driving. This paper also reviewed interventions that have proved effective in the developing world; concluding that more research needs to be done in developing countries to determine which preventative measures will have most effect, and that investment into safety measures needs to be increased.

In terms of data there are numerous reports produced by South African authorities on the number of vehicles and fatalities.

South African Statistics produced a report in 2009 using a national database of causes of death to examine trends of RTC deaths in SA from 2001–2006, showing an increase of crude death rates from 9 in 100,000 in 2001 to 11 in 100,000 in 2006 (11).

Mabunda used the National Injury Mortality Surveillance System for the 2001–2004 period to identify all pedestrian deaths from major South African cities, and showed that the majority of fatal RTCs occurred at the weekend and involved males, the majority of whom were under the influence of alcohol (12).

The South African Road Traffic Management Corporation has produced regular reports on the state of South African roads, using data from the SA police services, provincial traffic authorities and metropolitan municipalities to calculate the number of fatal crashes, roadworthy and unroadworthy vehicles, number of offences and statistics on the driver population (3,4).

However in 2007 Lagarde produced a review of the literature regarding RTCs in developing countries and stated that research was still scarce, and that there was a need for increasing research efforts (13).

Literature review – the cost of RTCs in South Africa

One aspect of research into RTCs that needs addressing is their cost. Schutte wrote a government report in 2000, stating that RTCs have a huge impact on South African society, including in terms of cost to the economy (14). He wrote that the government should be actively involved in addressing the problem, and that to add incentive reliable costs of RTCs were needed. The report used top-down, gross output costing methods, but didn't describe the calculations used to derive the hospital/medical costs. Their direct medical costs were on average R1912 per patient.

Olukoga used the same data from 1998 to produce gross output costs, and calculated that medical costs comprised 2.7 – 18.2% of the total cost, depending on crash severity (15).

In 2000 a retrospective review of all trauma patients admitted to a secondary level Durban hospital was carried out to determine costs using both bottom-up and top-down costing methods. They demonstrated a 20% difference between the two methods, and showed that femur fractures accounted for the large majority of hospital costs (16).

In 2004 there was a thorough review of trauma costing in South Africa in a report by the Medical Research Council and University of South Africa. They determined that critical debate on costing methodologies needed to be stimulated (17).

Since then only one other study of the cost of RTCs has been performed – a pilot study in Johannesburg costing the consumables used in the treatment of trauma patients. The study was of 48 patients (14 pedestrians in RTCs), using private costing charging sheets and procedures. The average for pedestrian injuries was R3885.97 (18).

The cost effectiveness of various interventions (enforcement of speed limits using mobile speed cameras, drink drive legislation, enforcement of seatbelts) has been proven by a 2012 study by Chisholm et al. They determined the expected population level effects of interventions over a 10 year period. They found that the effectiveness of each strategy varies by region, but combined strategies produce the most health gain (19).

Literature review – common patterns of injury in South African road traffic crash victims

Despite a number of papers describing the differences between the risk factors and mechanisms of RTCs in developing countries compared to the developed world, and the high burden of disease in South Africa, there is no South African literature on the common patterns of injuries seen.

Two retrospective US studies of 5000 and 115 pedestrian patients respectively both showed that musculoskeletal injuries were most common, followed by head and neck injuries (20,21). The larger study showed that the lower extremity was most commonly injured and had an overall mortality rate of 7.7%. The smaller and older study had an overall mortality rate of 22% but again showed that tibia-fibula fractures were mot common.

Another retrospective study of 180 patients in Sydney again showed that musculoskeletal and then head injuries were most common. Their mortality rate was 8.9%. They described three phases of pedestrian injury – the first as they impact the bumper and injure the lower limbs, the second and third as they impact against the bonnet and windscreen, and then the ground or another object. In the second and third phases head and torso injuries occur (22).

There are two prospective studies from the UK, both showing the same findings of lower limb and head injuries being the most commonly injured in pedestrian accidents (23,24). There is only one study of both pedestrian and motor vehicle occupants which demonstrated that pedestrians suffered more severe injuries, were more likely to be admitted to hospital, and were more likely to undergo surgery and spend longer in hospital (25).

Summary

Road traffic crashes are a significant problem globally. The problem is growing in developing countries, and there is evidence to suggest it's not being successfully controlled in our area of South Africa – Kwa-Zulu Natal.

Preventative measures have proved successful in developed countries, and their cost effectiveness has been proved in developing countries. Current literature emphasizes the need for further research in order to determine the most effective preventative measures depending on local risk factors.

Previous research also suggests that there needs to be greater investment into preventative measures – in terms of research and resources. In order for resources to be allocated or better distributed the cost of RTCs needs to be known. There are few costing studies of South African data, of varying methodology.

In order to prevent mortality from injuries sustained in RTCs, prompt medical management needs to be instigated. Knowledge of common patterns of injury will fill a gap in South African scientific literature and enable more efficient care of RTC patients in our area of Kwa-Zulu Natal.

3. Aims and objectives

Aim: To determine the burden of disease of road traffic accidents (RTCs) to a trauma centre in Kwa-Zulu Natal

Objectives:

1. To determine the severity of injuries of patients presenting after RTCs
2. To determine the mortality rate of RTCs in our area over a set period
3. To determine the common risk factors for injuries from RTCs
4. To determine the length of hospital stay, surgical requirements and outcome of patients injured in RTCs
5. To determine the direct medical costs of treating victims of RTCs
6. To determine common patterns of injury relative to mechanism of the RTC

4. Methods

This will be a prospective, epidemiological and costing study of victims of road traffic accidents presenting to Edendale Hospital in Kwa-Zulu Natal. Edendale Hospital is in a metropolitan complex that also includes a tertiary hospital and a district hospital. The complex provides specialised surgical services to a population of approximately three million people in the western part of Kwa-Zulu Natal Province. It drains patients from the urban and peri-urban areas of Pietermaritzburg as well as the deep rural areas of Sisonke Health District.

All patients presenting to the hospital after a road traffic crash during the study period will be included. Only those that occur on private land will be excluded. State mortuary data on victims that died prior to arrival at Edendale will be collected and included.

Data on injuries will be collected from patient records. Injuries will be defined radiologically, clinically or biochemically. Injury severity scores (ISS) will be attributed to each patient, by adding the square the score of the three most severe injuries sustained by each patient.

Cost will be calculated by recording all interventions on a 48hour basis. The price of radiological procedures will be taken from the South African Board of Healthcare Funders' National Health Reference Price list. The price of blood transfusions, laboratory tests and drugs will be calculated directly from our hospital's blood bank, laboratory and pharmacy pricing lists. The price of ward adjuncts such as NG tubes, urinary catheters, chest drains etc., will be calculated using the hospital's stock pricelist. The price of NG feeds and TPN will be taken from the dietetic department's pricelist.

If the patient has any operations the length of time spent in theatre will be obtained from theatre records. The price of theatre overheads such as lighting and heating per minute in theatre has been previously calculated in another study performed in our hospital (26). In addition to this cost an average cost of surgical sundries will be added to each case, and for orthopaedic cases the cost of any implants used will be taken from the patient's individual invoice.

Each individual patient's hospital stay (including length of stay in the Intensive Care Unit and High Care Unit) will be costed using the hospital overhead cost from the hospital Finance Manager.

Descriptive statistics will be used and paired t-tests will be used to compare significance between pedestrian and motor vehicle occupant patients. Significance will be inferred at $p = < 0.05$.

No specific significant endpoint is aimed for so the sample size will not require a specific power. The study period will last for 10 weeks.

5. Ethical considerations

This study doesn't involve any interventions, only data collection. Patients will be required to give verbal consent for their medical records to be reviewed and to be interviewed regarding the circumstances of the crash. We are applying to the Biomedical Research Ethics Committee for approval.

6. Budget

No funding is required.

7. Time lines

Data collection will take 10 weeks. Data analysis will take 2 months. Write up of the data will take 6 months.

8. Contributors

Name	**Department**	**Contribution**
Fran Parkinson	Department of Surgery, Edendale Hospital	First author
Damian Clarke	Department of Surgery, Edendale Hospital	Second author
Colleen Aldous	University of Kwa-Zulu Natal	Third author

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Appendix 3: Consent form

Consent form

I, the undersigned, consent to information I share with Dr Parkinson being used in the study ‘Morbidity, mortality and cost associated with taxi vehicle crashes in Pietermaritzburg – a prospective study’. The information will be kept anonymous and will be used for research purposes only.

....

Date:............/................../..............

Appendix 4: Information document

Information document

ROAD TRAFFIC CRASHES: THE BURDEN OF DISEASE TO A REGIONAL SOUTH AFRICAN HOSPITAL

Hello,

The surgical department at Edendale Hospital is doing research on road traffic accidents. Research is just the process to learn the answer to a question. In this study we want to learn how many people are injured in road traffic crashes what injuries they sustain and how much it costs the hospital to help them recover.

We are asking you whether we can use information about your crash and injuries in our study.

We are collecting information from 100 patients admitted to this hospital who have had road traffic crashes. We will ask you questions about your crash but apart from that you will not need to do anything other than let us read your medical records. We will then work out what injuries people tend to get in road traffic crashes, and how much is spent on treating them in hospital.

There is no risk to you should you be involved in this study.

We are hoping that the results of this study will highlight the importance of road safety, help in the management of similar patients in future and encourage more money to be spent on making roads in KwaZulu-Natal safer.

At completion we can supply you with the results of the study should you be interested.

Participation is voluntary. Refusal to participate will not affect your care in hospital. You may discontinue participation at any time without consequences to you or your care in hospital.

Every effort will be made to keep personal information confidential. Absolute confidentiality cannot be guaranteed. Personal information may be disclosed if required by law.

Organisations that may inspect and/or copy our research records for quality assurance and data analysis include groups such as the Research Ethics Committee.

Please contact Dr Fran Parkinson, Surgical Department, Edendale Hopsital, Pietermaritzburg, for more information.

For reporting of complaints/ problems:

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Chair: Email: Prof D R Wassenaar c/o ngwenyap@ukzn.ac.za

Appendix 5: Data collection sheet

Data collection sheet

Age	**Time of crash**
Sex	**Time of arrival to EDH**
Occupation	**Mode of transport to EDH**

Details of the crash – pedestrian/motor vehicle occupant/seatbelt use/alcohol/speed limit/weather

Description of injuries

Transfusions	**Days on NG feeds**	**Days on TPN feeds**
Vascular lines	**Urinary catheters**	**Drains**

Medication (dose and duration)

Radiological investigations

Biochemical and microbiological investigations

Other

Outcome					
Days in ICU		Days in High care		Days in EDH	
Died	Permanently disabled	Recovery with long rehab	Recovery with short rehab	Recovered	Referral to another hospital