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## PUBLIC HEALTH & PRIMARY CARE | RESEARCH ARTICLE

# Cost analysis of road traffic crashes in a tertiary hospital in Mpumalanga Province, South Africa

Busisiwe Precious Matiwane<sup>1</sup> and Ozayr Mahomed<sup>1\*</sup>

**Abstract: Background:** Road traffic crashes (RTCs) are an important cause of injury and fatality in low-middle-income countries. In South Africa, they result in 7.8% of gross domestic product losses. The aim of the study was to estimate the cost of inpatient management of RTC injured patients in a tertiary hospital in Mpumalanga Province between 1 April 2015 and 31 March 2016.

**Methods:** A cost analysis of patient care following a road traffic injury (RTI) was conducted using a mixed-costing approach. A retrospective review of hospital records was conducted to extract services consumed by patients during hospital admission between 1 April 2015 and 31 March 2016. Patient and financial records for the period 2015/2016 were used to obtain expenditure information. The bottom-up approach and top-down approach were used to calculate direct costs and indirect costs respectively. A sensitivity analysis was conducted to analyse how changes in resource use change the average costs. An average exchange rate of R13, 50 is equivalent to US\$1 was used.

**Results:** The majority of admissions were young males (72%) and those aged 20–34 years (53%). The patients were commonly injured in motor vehicle crashes (62%) sustaining head and neck injuries (32%) and fractures (23%). The total costs were R11,014,187 (US\$815,865) with direct and indirect costs amounting to



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### ABOUT THE AUTHORS

Busisiwe Precious Matiwane is a physiotherapist at Witbank Hospital in Mpumalanga Province, South Africa. She completed her master's degree in Public Health at the University of Kwa-Zulu Natal, South Africa in March 2018. The current study was conducted as part of her MPH degree and focused on costing road traffic injuries at a tertiary hospital to provide awareness of the burden of road traffic injuries on hospital budgets. Dr Ozayr Mahomed is a public health medicine specialist with extensive health system experience in South Africa. The research reported in this paper will form part of the body of research on costing studies in South Africa and hopefully elicit interest on further research in this area.

### PUBLIC INTEREST STATEMENT

Road traffic crashes impose both an economic and social cost on society. Road traffic crashes are associated with a high burden of injury and medical costs to hospitals. This study estimated the costs of managing road traffic injured patients and described the socio-demographic and clinical picture of road traffic injured patients. The findings revealed that direct care of patients accounted for high hospital costs compared to administrative and operational costs. An increased number of admitted road traffic injured patients will increase the injury burden of the hospital. Estimating the costs of managing patients with road traffic injuries can assist in proper budget allocations and advocacy for implementation of effective and sustainable information system related to road traffic injuries. The burden of injuries as result of road traffic crashes can provide insight on the extent and magnitude of the road safety problem in Mpumalanga Province.

R5,995,872 (US\$444,138) and R5,018,315 (US\$371,207) respectively. The average cost per patient per day for RTIs was R256,382 (US\$18,991).

**Conclusion:** The economically active population and male gender were high risk groups with the main cost drivers being surgical sundries and medication. Direct management of patients accounted for high hospital costs. It is recommended that in addition to implementing a multipronged health promotion intervention to reduce the burden of RTCs, a further cost analysis using a time-motion study of patients admitted with RTIs be conducted to correctly analyse the costs incurred by the hospital.

**Subjects:** Economics, Finance, Business & Industry; Health and Social Care; Medicine, Dentistry, Nursing & Allied Health

**Keywords:** road traffic crashes; road traffic injuries; cost analysis; tertiary hospital; South Africa

## 1. Introduction

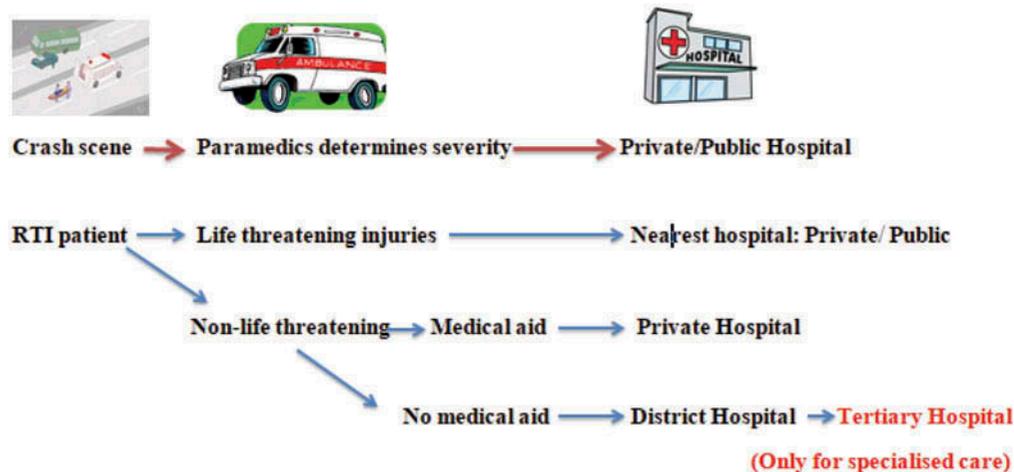
Road traffic crashes (RTCs) are a major cause of injury and death (WHO, 2013) accounting for an estimated 1.25 million deaths (WHO, 2015) and 50 million non-fatal injuries per annum globally in 2013 (Toroyan, 2013). The number of RTC deaths globally has remained constant since 2007, showing a reduction in deaths due to RTC regardless of the increase in automobiles and the population (Toroyan, 2013). Globally, road traffic injuries (RTIs) are projected to be the ninth leading cause of death in all age groups and are expected to become the seventh leading cause of death by 2030 (WHO, 2015).

Approximately 73% of all RTC deaths occur in men (WHO, 2015) and have been listed as the primary cause of fatality in those aged 15–29 years (Toroyan, 2013). About 90% of RTC fatalities occur on roads in low-and-middle-income countries despite the fact that these countries have almost half of the world's registered automobiles (WHO, 2015). In Africa, 25% of all injury-related deaths are due to RTCs (Ncube, Lufumpa, Kayizzi-Mugerwa, & Murinde, 2013).

South Africa (SA) has witnessed a rise in RTIs in 2013 and RTIs have moved from the 10th to the 9th leading cause of premature mortality resulting in 2.6% of years of life lost (Massyn N et al., 2015). In 2014 transport crashes were the third most common reason of unnatural fatalities at 12.4% (5,926 cases classified as transport crashes) and made up 1.3% of both natural and unnatural causes of death (Lehohla, 2015). Transport crashes were the second primary cause of mortality in Northern Cape 30.3% (474 cases), Free State 18.1% (574 cases), Mpumalanga 11.4% (421 cases) and Limpopo 29.5% (1,164 cases). The percentage of deaths caused by transport crashes were the highest in Northern Cape, followed by Limpopo and lowest in Gauteng 3.5% (474 cases) followed by Western Cape 8.7% (520 cases). Conversely, Limpopo had the highest number deaths due to transport crashes, with 1,164 deaths compared to 474 for Northern Cape (Lehohla, 2015).

In SA when a person is involved in a RTC, the first level of assistance is from bystanders who either call the ambulance or take the person to the nearest hospital. The paramedics initially check if the person has medical aid or not and this will determine if the person is taken to a public or private hospital. Emergency medical response personnel will triage the patients and if the patient's condition is life-threatening they will transfer the patient to the nearest hospital (private or public). If the patient does not have medical aid and if the patient's injuries are not life-threatening, they will be transferred to the nearest district hospital. Patients will be assessed and provided the necessary clinical care that is possible at a district hospital. If the patient's condition is serious and requires major surgical or orthopaedic intervention, the patient will be referred to a regional or tertiary hospital (Figure 1).

**Figure 1. RTI patient from accident scene to medical care and treatment in hospital. (Source: Researcher developed.)**



A study conducted in Kwa-Zulu Natal indicated that five RTI patients are admitted per day (Parkinson, Kent, Aldous, Oosthuizen, & Clarke, 2013b) and the average cost of care of a pedestrian and vehicle occupant in an RTC was found to be US\$6,789 and US\$7,127, respectively, and the total cost of inpatient hospital management of admitted RTI patients for 10 weeks was US\$698,850 (Parkinson, Kent, Aldous, Oosthuizen, & Clarke, 2014). Furthermore there is a high burden of injury linked with RTCs at hospitals (García-Altés & Pérez, 2007, Mthembu, 2012, Parkinson et al., 2013b). Despite the increased burden of RTIs on hospital admissions and budgets, there is a paucity of studies that have researched the costs of managing patients with RTC injuries in SA (Xu et al., Macharia, Njeru, Muli-Musiime, & Nantulya, 2009). This study will assist in revealing the financial cost of RTCs in Mpumalanga and assist public hospital managers in proper budget allocations. The aim of the study was to analyse the cost of RTC injured patients in a tertiary hospital in Mpumalanga Province.

## 2. Material and methods

### 2.1. Study location and site

The study was conducted at Witbank Hospital, a tertiary hospital in Mpumalanga Province. Witbank hospital is a 350-bed referral hospital in Nkangala district in Mpumalanga. Nkangala district is made up of six sub-districts: Dr JS Moroka, Emakhazeni, Emalahleni, Steve Tshwete, Thembisile Hani and Victor Khanye. The population of the district is 1,382,414 with a population density of 81 people per km<sup>2</sup> and is categorized within socio-economic Quintile 4 (Massyn et al., 2015). The hospital also offers services to Gert Sibande district and some of the Ehlanzeni district. Witbank hospital has almost 1,038 professionals and support staff. The hospital offers the following essential services 24 h: trauma casualty, laboratory, radiology. The radiology department offers X-rays, CT scans and ultrasound for emergencies. An RTC injured patient is admitted via the trauma casualty and is either taken to the intensive care unit (ICU), surgical wards or orthopaedic ward depending on the type of injuries. There are two ICUs, one adult ICU and one neonatal ICU.

### 2.2. Study population

The study population consisted of all road traffic injured patients admitted at Witbank Hospital after an RTC between the 1st of April 2015 and the 31st of March 2016. All the patients admitted for injuries due to RTCs between 1st of April 2015 and 31st of March 2016 made up the sample of the costing study.

### 2.3. Data collection

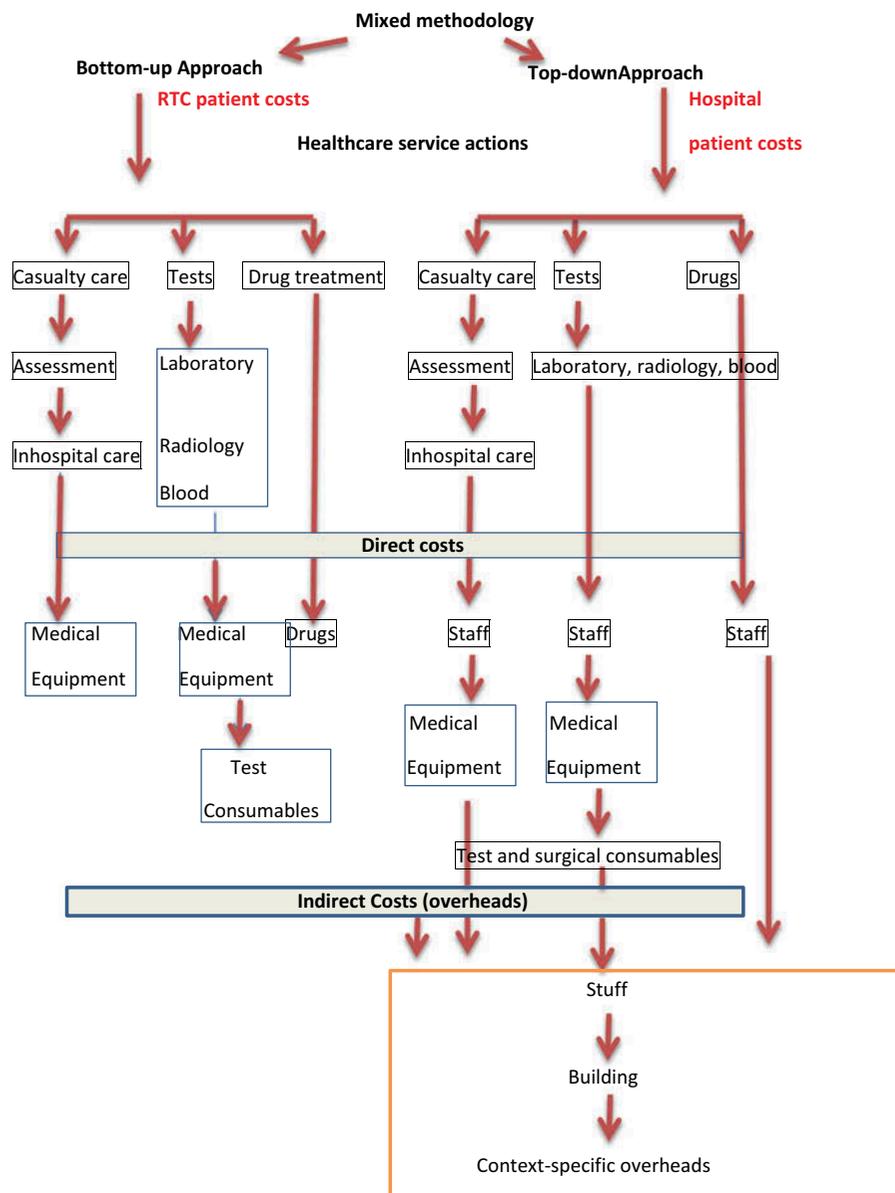
An adapted checklist was employed to collect the required information which consisted of: demographic information, crash details, admitting unit, injury details, area of injury, treatment, allied medical treatment, laboratory investigations, radiological investigations, blood products.

Investigations and any procedures performed were obtained from the patient’s medical records. Facility data, land and building, human resource, furniture and equipment, utilities, were obtained from the finance, human resources and systems departments. Financial records, furniture and equipment records, land and building records, human resource and facility data were assessed and the information was captured using the data collection tool.

**2.4. Data analysis**

A mixed-costing approach was employed to analyse the costs of RTC injured patients (Figure 2). The land and building section of the data collection tool was excluded because the information was not available from the facility. Staff salaries were recorded as one cost centre in the hospital expenditure report and thus staff salaries per category could not be determined. Compensation of employees was used instead of staff annual salaries and this was costed using the top-down approach. The patient day equivalent (PDE) percentage for the RTC patients was used for allocation of costs in the top-down approach. The RTC PDE percentage was multiplied by the total operational

**Figure 2. Conceptual framework for the mixed-costing approach.**



and human resource costs of the hospital to obtain the proportion used by the RTC injured patients. The cost per patient based on the length of stay (LOS) and the cost of illness (RTC admission) were calculated. PDE is an indicator that measures how a hospital spends available funds and is a sign of efficiency. It is used to calculate the average cost per PDE at a district hospital and is expressed in Rands per PDE (Massyn et al., 2016).

The bottom-up approach was conducted by costing resource use by RTC injured patients using hospital medical records. Each activity such as medication, laboratory, blood products, radiology, surgical sundries (implants, screws, plates, nails and wires used during surgical procedures in theatre) and consumables (gloves, needles, test tubes, test kits) used by RTC injured patients was retrieved from medical records. The cost per activity was multiplied by the total number of tests conducted and these were added to obtain a total cost per patient. The total LOS in hospital was calculated for the RTC injured patients and the total admission days were also calculated.

Furniture and computers were depreciated over a 3-year period and equipment were depreciated over a 6-year period.

An exchange rate of R13, 50 equivalent to US\$1 was used.

#### *2.4.1. Dealing with uncertainty*

Cost estimations are subject to uncertainty (Briggs et al., 2012). Parameter uncertainty is an important factor to consider in costing studies, this could be due to differences in estimation of variables such as staff time spent per patient as a result of missing data. The median costs of road traffic (from Table 2) admission were assessed using sensitivity analysis. Baseline costs were formulated as a basis for comparison with the results from the sensitivity analysis scenario forecasting. The low and high interquartile range (IQR) costs obtained from the components costs of direct patient costs were used to formulate the low and high baselines average costs.

#### *2.4.2. Scenario forecasting*

Four forecasting scenarios were created to check how changes in resource use by the RTI patients changed the average costs. In the first forecasting scenario, the assumption was that more time was spent on RTI patients as a result of their complex injuries. Therefore the staff salaries were adjusted to 4% (from Table 2) of the total human resource (HR) costs. In the second scenario, the sensitivity analysis was based on 1% (from Table 2) of the RTC PDE. The indirect costs were adjusted to 1% PDE. In the third scenario, the sensitivity analysis was based on a 20% increase of the direct costs and a 4% increase in indirect costs. In the fourth scenario, the direct costs were decreased by 20% with no alterations to the indirect costs. The average costs were calculated for each of the four scenarios and these were compared with the RTC average in conjunction with the low and high baseline costs.

### **2.5. Ethical consideration**

Ethical approval was obtained from the Biomedical Research Ethics Committee; reference number BE429/16. Permissions were obtained from the hospital manager of Witbank Hospital and the Mpumalanga Provincial Health Research and Ethics Committee (REF: MP\_2016RP42\_120).

## **3. Results**

### **3.1. Overview of study participants**

During the financial year period, 1 April 2015 to 31 March 2016 road traffic injured patients accounted for 1.6% of total admissions and 4.5% of the total LOS for patients. A total of 23,886 patients were admitted at Witbank Hospital and the total LOS was 99,474 days of which a total of 393 RTC injured patients were admitted with a total LOS of 4,481 days. Of the 393 RTC admissions, only 208 patients fulfilled the inclusion criteria, 150 (72%) were males and 58 (28%) were females with a mean age of 29 years. Sixty percent of patients were below 35 years of age.

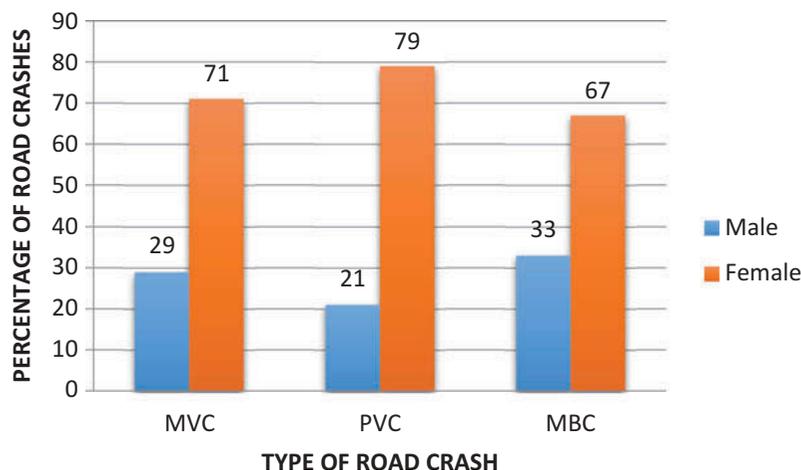
Motor vehicle crashes (MVCs) were the most common type of RTC (62%) followed by pedestrian vehicle crashes (PVCs) (35%) and then motorbike crashes (MBCs) (3%). The gender distribution was high across all types of RTCs but was particularly high among pedestrians, where 79% were male pedestrians and only 21% were female pedestrians (Figure 3). The majority of RTI patients were admitted in the orthopaedic wards 51% ( $n = 105$ ) followed by surgical wards with 39% ( $n = 82$ ) and 10% ( $n = 21$ ) in the adult ICU. For the adult ICU ward the mean LOS was 7.45 (standard deviation (SD): 9.23) days; for the surgical ward the mean LOS was 10.6 days (SD: 11.1) days), and for the orthopaedic ward the mean LOS was 22.7 days (SD: 20.3). The most commonly injured body region was the head and neck 32% ( $n = 187$ ), followed by the lower limbs 28% ( $n = 154$ ) and upper limbs 20% ( $n = 113$ ). The most common type of injury were fractures 23% ( $n = 204$ ), lacerations 16% ( $n = 95$ ), abrasions 14% ( $n = 84$ ) and contusions 13% ( $n = 81$ ) (Figure 4). Of the 216 injuries sustained by the 208 RTC patients, 66 patients had more than 3 injuries. One hundred and six patients required surgery, 164 operations were performed with 7 patients having three surgeries. Patients involved in MVCs had the most surgical interventions 60% ( $n = 64$ ), followed by PVCs 35% ( $n = 37$ ) and MBCs 5% ( $n = 5$ ).

### 3.2. Cost analysis

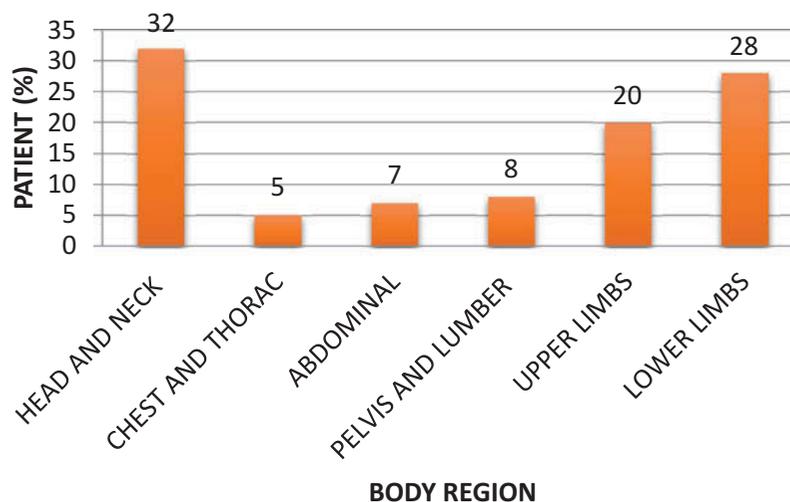
#### 3.2.1. Total costs

The total cost of injuries sustained by the 208 RTC patients was R11,014,187 (US\$815,865) which is equivalent to 2.4% of the total 2015/2016 hospital expenditure (R459,236,788; US\$34,017,539). The direct RTC costs accounted for 54% (R5,995,872; US\$444,138) while indirect costs accounted for 46%

**Figure 3. Percentage of males versus females involved in the different types of crashes.**



**Figure 4. Distribution of injuries according to body regions.**



**Table 1. Allocation of costs to RTC patients costs**

Activity	RTC indirect medical costs	RTC indirect costs (%)	Direct activity	RTC direct medical costs (actual)	RTC direct medical costs (%)
Compensation of employees	R3,040,629	61	Medication	R1,743,216	29
Good and services	R1,574,628	31	Laboratory	R161,203	3
Equipment (depreciation)	R153,889	3	Blood Products	R308,885	5
Medicines-non-specific	R231,542	5	Radiology	R506,035	9
Consumables-non-specific	R17,627	0	Surgical sundries (specific)	R2,604,024	43
			Consumables-specific	R672,509	11
<b>Total</b>	<b>R5,018,315</b>			<b>R5,995,872</b>	<b>100</b>

(R5,018,315; US\$371,727) of the total RTC costs (Table 1). The cost per patient per day was (R2,563; US\$18,985) for RTC patients based on the LOS and R6,358 (US\$47,096) per patient day equivalent.

### 3.2.2. Component costs

Compensation of employees made up 61% (R3,040,629; US\$225,232) and good and services made up 31% (R1,574,628; US\$116,639) with regard to RTC indirect costs. Surgical sundries 43% (R2,604,024; US\$192,817); medication 29% (R1,743,216; US\$129,127) and consumables 11% (R672,509; US\$49,815) were the main direct cost drivers. The total costs of surgical sundries for all 106 patients was R2,604,024 (US\$192,817) and 97% of the surgical sundries costs were for implants costing R2,538,209 (US\$188,015) with 83% of the implants costs were for orthopaedic services and 16% were neurosurgery.

Medication contributed 96% (R1,662,843; US\$123,173), nutritional feeds, dressing products and intravenous fluids accounted for 4% (R80,373; US\$5,954) of the pharmaceutical cost. Consumables (R672,509; US\$49,815), Radiology (R506,035; US\$37,484), Blood Products (R308,885; US\$22,880) and Laboratory test (R161,203; US\$11,940) accounted for 11%, 9%, 5% and 3% of the component costs respectively (Table 2).

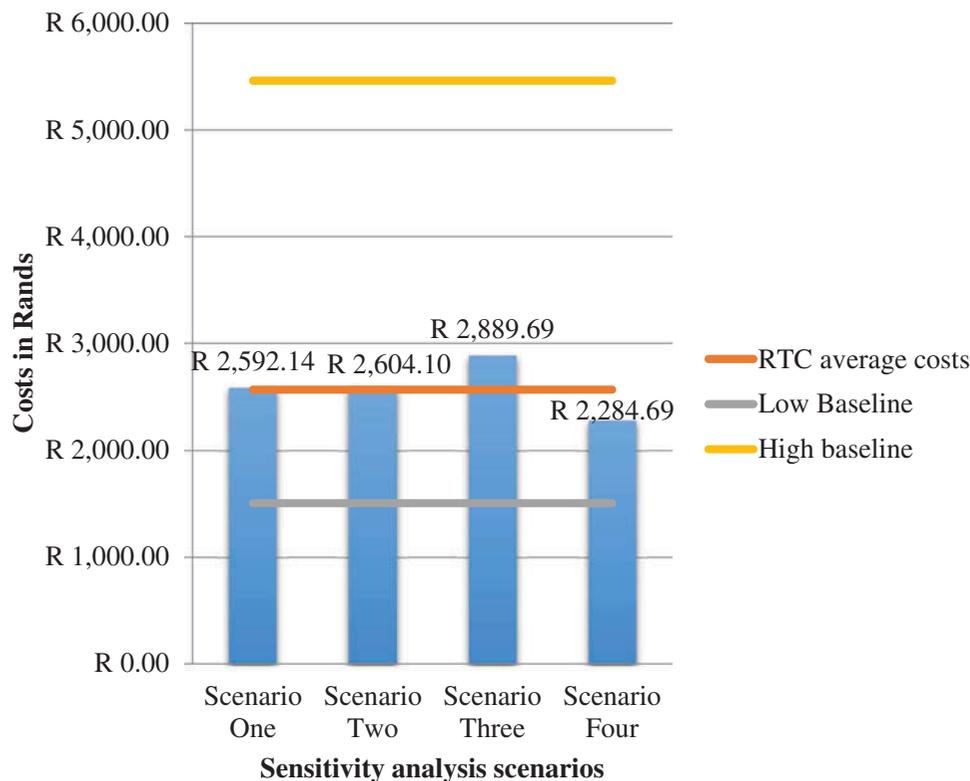
### 3.2.3. Sensitivity analysis

Two baseline costs were created and were used in conjunction with the RTC average costs to compare with the results from the sensitivity analysis. The two baseline costs were created using the IQR costs of

**Table 2. Breakdown of component costs**

Direct activity	Total costs in Rands (R)	Percentage (%)	Median cost per patient in Rands (IQR)
Medication	R1,743,216	29	R19,118 (R36–R117,504)
Laboratory	R161,203	3	R74,684 (R15,031–R241,695)
Blood products	R308,885	5	R650,592 (R215,648–R2,186,217)
Radiology	R506,035	9	R424,650 (R2,980–R11,771)
Surgical sundries (specific)	R2,604,024	43	R14,880 (R136,910–R46,170)
Consumables-specific	R672,509	11	R840 (R15,232–R527,796)
<b>Total</b>	<b>R5,995,872</b>	<b>100</b>	

**Figure 5. Average costs from the sensitivity analysis scenarios showing the baseline costs.**



the component costs (Table 2). The low baseline costs were R149,951 (US\$111) and the high baseline cost was R546,143 (US\$405) (Figure 5).

### 3.2.4. Scenario modelling (forecasting)

Costs estimates are subject to a level of uncertainty. Four scenarios were created to eliminate uncertainty in the cost estimates. In the first scenario, the assumption was that more time was spent on RTC injured patients as a result of their complex injuries. Therefore the staff salaries were adjusted to 4% of the total human resource (HR) costs. Increasing HR costs by four percent will increase total costs by only 1.1%. The cost per patient per day was R2,592 (US\$192) (Figure 5). In the second scenario, the sensitivity analysis was based on 1% of the RTC PDE. The indirect costs were adjusted to 1% PDE. Increasing indirect cost by 1% will increase total costs by 1.5%. The cost per patient per day was R2,604 (US\$193) (Figure 5).

In the third scenario, the sensitivity analysis was based on a 20% increase of the direct costs and a 4% increase in indirect costs. Increasing the direct costs by 20% and decreasing indirect costs by 4% will increase the total costs by 11.3%. The cost per patient per day was R288,969 (US\$214) (Figure 5). In the fourth scenario, the direct costs were decreased by 20% with no alterations to the indirect costs. Decreasing the direct costs by 20% will decrease total costs by 12.2%. The cost per patient per day was R228,469 (US\$169) (Figure 5).

## 4. Discussion

The RTC caseload in the current study is lower than the findings shown in a cross-sectional study conducted over a year in Johannesburg at a level 4 hospital, where the caseload of RTC was 1,240 patients (Mthembu, 2012). In addition, the caseload in the current study is lower than a cross-sectional study conducted at a tertiary referral hospital between September 2014 and August 2015 in Addis Ababa that showed a caseload of 799RTIs (Getachew et al., 2016). The higher caseload in the Addis Ababa study could be the result of weak road safety plans and the

inability of drivers to abide by traffic laws (Getachew et al., 2016). However, the differences between the current study and that of the Johannesburg study could be attributed to high traffic volumes (Municipality, 2015), challenges with road maintenance, limited power and resources in terms of metro police and emergency services in Johannesburg (Municipality, 2017). In addition, the low number of RTC admissions in the current study could be because there are no specific requirement or regulation compelling facilities to collect data on RTCs and record it and the available data on RTIs is often incomplete and limited in Africa (Ncube et al., 2013).

The findings of the current study are consistent with international and local studies with a male predominance, an overall younger population with a mean age of 29 years. The young age group in the current study represents the economically active age groups and the economic productivity results in higher movement of this age group (Chauhan et al., 2014). The male predominance in the current study could be as a result that there more males exposed to RTIs than females across all the different types of RTCs.

The findings in terms of types of RTC-MVCs (61%), PVCs (35%) and MBCs (3%), were similar to other studies in Pietermaritzburg in Kwa-Zulu Natal (Parkinson, Kent, Aldous, Oosthuizen, & Clarke, 2013a) and in Nairobi Kenya (Osoro, Ng, Oundo, Omolo, & Luman, 2011), and differed from a retrospective cross-sectional study conducted in Ethiopia that found most of the RTI patients were pedestrians 60% ( $n = 97$ ), followed by those in MVCs 23% ( $n = 33$ ) and by motorcyclists 1% ( $n = 2$ ) (Getachew et al., 2016). The high proportion of MCAs in the current study could be due to the high traffic volumes caused by the constant urban development which places a burden on the old and deteriorated roads with potholes. This is further heightened by the lack of a master road plan in the municipality to maintain roads (Municipality, 2016). Alcohol was found to have played the main role in pedestrian injuries in SA while the absence of adult supervision was the major contributing factor in child pedestrian injuries (Norman, Matzopoulos, Groenewald, & Bradshaw, 2007).

#### **4.1. Injury details**

There is a consensus in the international literature that the most common site of injury is the head and neck and extremities with fractures being the most common type of injury. The findings from the current study showed that the most commonly injured body region was the head and neck 32%, followed by the lower limbs 28% and upper limbs 20%. In the current study RTC patients were mainly involved in MVCs and PVCs. Head injuries commonly occur in frontal collisions where the unrestrained vehicle occupant hits the windscreen and when unrestrained the vehicle occupant is ejected out of the vehicle. While pedestrians sustain head injuries following a fall after a PVC and the head hits the ground. Motorcyclists sustain injuries to the lower extremities and sustain head injuries in the absence of helmets (Bowley & Boffard, 2002).

#### **4.2. Cost analysis**

The total cost of injuries sustained by the 208 RTC patients was equivalent to 2.4% of the total 2015/2016 hospital expenditure which was higher to the findings reported in a Johannesburg study where the total cost for 259 patients accounted for only 1% of the total hospital expenditure (Mthembu, 2012). However, a study in Iran showed that the total costs of 1,155 RTC patients accounted for 7.4% of the total hospital expenditure (Sargazi et al., 2016). The low percentages found in the current study were mainly due to the small RTC caseload.

In the current study direct costs and indirect costs made up 54% and 46% of the total costs respectively. The direct costs are lower than those found in a cross-sectional study conducted in Iran that showed treatment costs (direct costs) and indirect costs (utility costs) made up 88% (US \$58,944,849) and 12% (US\$7,721,821) respectively (Sargazi et al., 2016). In addition, the findings from the current study were lower than those of a prospective cohort study conducted in a General Hospital in Vietnam from January 2010 to August 2010, which found that direct medical costs made up 75% of the total costs (Nguyen et al., 2013) (Table 3). The indirect costs were low in the

**Table 3. Comparison of costing studies**

Author, year	Study location	Study sample	Perspective of costing	Total costs	Study period	Average cost	Direct medical	Direct non-medical costs	Indirect costs
(Manouchehrifar, Hatamabadi, & Derakhshandeh, 2014)	Third-level Imam Hossein Hospital, Iran	200 patient files	Provider (hospital) perspective	x	1 year	\$1,622.1	x	x	x
(Nguyen et al., 2013)	Thai Binh General Hospital	477 participants	Individual and family perspective	x	8 months	US\$367	75% of total costs Pedestrians (US\$306), car occupants (US\$296), bicyclists (US\$274) and motorcyclists (US\$261)	Car occupants (US\$61), pedestrians (US\$58), motorcyclists (US\$44) and bicyclists (US\$43)	✓ NS
(Nguyen et al., 2013)	Edendale Hospital, South Africa.	100 patients	Provider	US\$698,850	10 weeks	PVA was US \$6,789 and MVA was US \$7,127	✓	x	x
(Sargazi et al., 2016)	Amir-Al-Momenin Hospital, a secondary healthcare centre	1,155 RTA victims	Provider and patient	US\$58,944,849	1-year period	US\$363	✓ US\$56,659,718	x	✓ US\$7,721,821
(Mthembu, 2012)	Charlotte Maxeke Hospital	259	Provider	R957,059,011 (2009)	1 year	R265,580 (2009)	Classified as variable costs 30% of total costs R260,486,611	x	Classified as fixed costs 70% of total costs R69,652,400
Current study	Witbank Hospital, tertiary	208	Provider	R11,014,187 US\$815,865	1 year	R2,563 (US \$18,985)	R5,995,872 (US\$444,138) 54% of total costs		R5,018,315 (US\$371,727) 46% of total costs

Notes: Direct costs: costs that are linked to a utilisation of a resource and can be traced back to a patient (Mogoroso & Smith, 2005); Direct non-medical: costs incurred by the patient and caregivers such transportation; Indirect costs: loss of productivity (Nguyen et al., 2013) and/or costs incurred by the hospital that cannot be directly linked to a patient such as security (Mogoroso & Smith, 2005); x: not included; ✓: included; NS: not specified.

current study as a result of the small RTC caseload which affected the proportion of HR costs apportioned to RTC patients and resulted in HR costs amounting to only 28% of the total costs.

The main cost drivers in the current study were compensation of employees, surgical sundries and medication amounting to 28%, 24% and 16% of the total costs respectively. Human resource costs accounted for 28% of the total costs and were strikingly lower than the hospital HR costs which accounted for 65% of the total costs and the Johannesburg study where salaries accounted for 43% of the total costs (Mthembu, 2012). The low salary costs in the current study were due to a small caseload and the Johannesburg study had higher salary costs typical of a level 4 hospital. The differences in HR costs seen in the current study could be the result of the low RTC caseload that consequently resulted in a low PDE and the low PDE reduced the HR costs apportioned to the RTC patients.

The high usage of surgical sundries could be attributed to the 51% of RTC patients that required surgical intervention. The major cost driver of the surgical sundries was implants, which accounted for 97% of the surgical sundries costs and 23.6% of the total costs. The findings of the current study are higher than that of a prospective cross-sectional study from Pietermaritzburg, SA where implants made up 18% of the total costs (Parkinson et al., 2014). The potential reason for this differential use and cost of implants was that 106 RTC patients were operated in the current study compared to 90 RTC patients in the Pietermaritzburg study (Parkinson et al., 2014).

In the current study medication was the third highest cost accounting for 16% of the total costs, lower percentages were shown in the study in Johannesburg where medication made up 2.6% of the total costs (Mthembu, 2012), while higher medication usage was shown in a descriptive cross-sectional study conducted in two major cities in Nepal from August 2008 to September 2008 where medicines made up 41% of the total facility costs (Joshi, 2009). The high usage of medication in the current study could be attributed to the large volumes of expensive anaesthetic medication used during surgical interventions, the prolonged use of enteral and parenteral nutrition given especially to patients with head injuries and medication was often given twice daily for an average of 20.6 days.

The low average costs per day in the current study were mostly the result of the low percentage of RTC admissions and a low percentage of hospital stay in comparison to patients in the other sectors of the hospital. The higher cost per day in the Johannesburg could be due to the complexities of injuries sustained by their patients, the fact that specialised management of patients at a level 4 hospital is costly and salaries were a cost driver in this study as a result of the specialist healthcare professionals at a level 4 hospital.

#### **4.3. Strengths and limitation**

The strengths of the cost analysis include: the study was conducted over 1 year during a financial period so that hospital utilisation could be obtained from complete financial records and to include seasonal effects on resource utilisation. In addition, the information in the data collection tool covered the objectives of the study and a mixed-costing approach was used to counter for missing data.

Although due diligence was maintained to ensure the scientific integrity of the study, the following were some of the limitations: The cost analysis was compromised by missing data of some of the cost items and resulted in the use of PDE for calculating costs. The hospital information is not very well developed and therefore not all the cost information was available. Staff salaries accounted for 65% of the total 2015/2016 hospital expenditure, but they could not be calculated per patient and this was a limitation of the study. Despite including all RTC injured patients admitted for more than a day, it was not possible to increase the study sample size above 208. The limitations of the study were a small sample size, information bias caused by missing hospital files and incomplete records; and selection bias because the study is only generalizable to tertiary hospitals.

## 5. Conclusion and recommendations

This study is one of the few costing studies conducted in SA on RTIs and despite the shortcomings of the data; it will provide a basis for further research. Road traffic injuries affect mostly males and the economically active individuals resulting in increased economic burden to the country, health-care system and households. Motor vehicle occupants were commonly injured in RTCs sustaining head and neck injuries and fractures. The study recommends an improvement in the health information system as well as a time-motion study of patients admitted with RTIs at the hospital. This will allow for an activity-based study to accurately analyse the costs incurred by the hospital as a result of RTIs. In addition, a holistic health promotion campaign targeting individual behaviour change should be incorporated in the overall strategy to reduce RTIs.

## Nomenclatures

ICU	intensive care unit
IQR	interquartile range
MBCs	motor bike crashes
MVCs	motor vehicle crashes
LOS	length of stay
PDE	patient day equivalent
PVCs	pedestrian vehicle crashes
RTCs	road traffic crashes
RTI	road traffic injuries
SA	South Africa
SD	standard deviation
WHO	World Health Organisation

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