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Original article

Severe traumatic brain injuries secondary to motor vehicle crashes in two Namibian regions: A retrospective review

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ABSTRACT

Introduction: Traumatic Brain Injuries (TBIs) are a leading cause of morbidity and mortality among trauma patients globally, with motor vehicle crashes (MVCs) being a major contributor. Namibia had a World Health Organization (WHO) estimated MVC-related fatality rate of 30.4 per 100 000 population in 2016, higher than that of the African continent, while no epidemiological studies describing the distribution and determinants of TBIs exist in the country. The study aimed to describe the characteristics of adult patients (≥18 years) with severe TBI secondary to MVCs which occurred in two regions of Namibia between the years 2014–2018.

Methods: A retrospective descriptive observational study was conducted in adult patients who sustained severe TBIs secondary to MVCs in two Namibian regions. The inclusion criteria were patients ≥18 years with a severe (as described on the Motor Vehicle Accident Fund system) MVC-related TBI who sustained an injury in the Otjozondjupa or Khomas regions between the years 2014–2018.

Results: A total of 87 patients met the inclusion criteria, 65 (74.7%) from the Khomas region, and 22 (25.3%) from the Otjozondjupa region. The overall mean age of patients was 34 years (*SD* 11.79), most were male ($n = 78$. 89.7%) and 55.2% ($n = 48$) of all patients sustained an isolated TBI. The majority of the patients were admitted to a state healthcare facility ($n = 52$, 59.8%). Pedestrians were the most injured ($n = 34$, 52.3%) in the Khomas region while vehicle drivers were the most injured ($n = 11$, 50%) in the Otjozondjupa Region. A total of 34 (39.1%) patients died and 53 (60.9%) were discharged from hospital. Overall, there were no statistically significant relationships between patient outcomes and independent variables.

Conclusions: The study was to our knowledge the first to describe the epidemiology of TBIs in Namibia. Young individuals are the main people who sustained TBIs, which may subsequently place a socio-economic burden on the country. There is however limited research in Namibia to guide healthcare planning.

African relevance

- Provide the first quantitative description of TBI epidemiological characteristics in Namibia
- Develop a broader understanding of the impact of MVAs in the Namibian setting
- Empower healthcare sector planning and possible intervention
- Develop a platform for further research

Introduction

Traumatic Brain Injuries (TBIs) have become a global health and socio-economic concern and a major contributor to morbidity and mortality amongst trauma patients [1]. The estimated incidence of TBIs, globally, was 10 million cases per annum and 150 cases per 100 000 population in the United States of America (USA) in 2007 [1]. About 4.8 million people died worldwide in 2013 secondary to a TBI and many more were left disabled [2]. The annual (direct and indirect) medical costs of TBIs in the USA in the year 2009 (USD 302 million and USD 2.8 billion, respectively) demonstrate the significant financial burden caused by TBIs [3].

Motor vehicle crash (MVC) related injuries have increased over the last 30 years with MVCs recognised as the leading cause of TBIs [1,4]. The highest number of MVCs emanates from Africa and South-East Asia [1]. Males sustain TBIs more frequently than females with the age of those injured ranging mainly between 20-40 years [5] and it is a major causative factor of morbidity and mortality amongst young adults

Abbreviations: ECC, Emergency Communications Centre; LMICs, Low- and middle-income countries; MVCs, Motor Vehicle Crashes; TBIs, Trauma Brain Injuries; WHO, World Health Organization.

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globally [6]. The 2018 World Health Organization (WHO) global status report on road safety states that low- and middle-income countries (LMICs) have 85% of the world's population and 60% of the world's registered vehicles while 93% (13% and 80%, respectively) of MVC-related deaths occurs here [7]. In 2013, MVC-related injuries were estimated to cost LMICs between 1% and 2% of their gross national product [8]. Although MVC-related injuries have increased over the last 3 decades, the mortality rates in South Africa and a few other African countries may be decreasing and likely attributed to the development of pre-hospital systems in these regions [4]. Severe TBI patients commonly require lengthy hospital admissions, and the survivors may require long-term rehabilitation for conditions secondary to the TBI, some from which patients never fully recover [6].

Namibia is a sparsely populated, upper-middle-income country in Southern Africa with vast distances between towns. Tertiary level hospitals are mainly located in the capital city, Windhoek (Khomas Region) where patients can receive definitive care. These challenges are further compounded by the high rate of MVCs exerting more pressure on the already resource-limited facilities. The WHO (2018) states that MVC-related death rates are highest in Africa at 26.6 per 100 000 population, however, Namibia had an estimated MVC-related death rate of 30.4 per 100 000 population in 2016 [7]. With no published data on the distribution and determinants of TBIs in Namibia and Namibia identified as a country with a high rate of MVC-related deaths [7], the results of this study will be valuable, allowing the first description of TBI characteristics in Namibia, broadening the understanding of the impact of MVCs, and develop a platform for further research. The study aimed to describe and compare the characteristics of adult patients with severe TBI secondary to MVCs which occurred in two Namibian regions between 2014 and 2018 as captured by the Motor Vehicle Accident (MVA) Fund of Namibia.

Methods

Study design

A descriptive observational study in the form of a retrospective review was conducted to describe the characteristics of adult patients who sustained a severe TBI secondary to a MVC in 2 Namibian regions (Khomas & Otjozondjupa).

Study setting and population

Namibia has a population of about 2.5 million [9] and is divided into 14 regions including the Khomas and Otjozondjupa regions. The Khomas region is centrally located with most of the population residing in Windhoek [10]. Otjozondjupa region, one of the biggest regions, has 4 district hospitals [11] providing emergency care but not definitive care, for which patients require inter-hospital transfers (road or air) to tertiary hospitals in Windhoek. The hospitals are located in Okahandja, Otjiwarongo, Okakarara and Grootfontein. Okahandja is closest to Windhoek at 72km while Grootfontein is the farthest at 458 km. The 2 regions contain four of the five top roads for crash location and severity identified in Namibia and recorded some of the highest injury and fatality rates in the country in the period under study, hence the selection as the study setting [12–17].

Established in 1991, the MVA Fund of Namibia is an organization that designs, develops, promotes, and implements MVC injury prevention measures and aid persons injured in road crashes. As part of assisting MVC victims, the MVA Fund operates a national 24-hour emergency communications centre and emergency medical response services with bases in various towns across the country. The main source of data is the MVA Fund Emergency Communications Centre (ECC), where crashes are reported, through the Toll-free Accident Response Number. Information collected and recorded by the ECC is verified with the Namibian Police, Emergency Medical Rescue Services - Paramedics and Health Officials from public and private hospitals throughout the country. Only crashes which result in injuries are recorded by the MVA Fund ECC. Hence, crashes that result in property damage only, are duly excluded [13–17].

The study population were adult patients (≥18 years old) who sustained a severe TBI (as classified in the MVA Fund system) secondary to an MVC in the Khomas region and Otjozondjupa region in Namibia between the 1st of January 2014 and the 31st of December 2018. The classification of severe TBI is recorded on the MVA Fund system as made by the clinical evaluation of the treating physician.

Inclusion and exclusion criteria

The inclusion criteria were as follows:

- Adult patients (≥18 years)
- Severe TBI (as classified in the MVA Fund database)
- Injury sustained in the Khomas or Otjozondjupa region between 1 January 2014 and 31 December 2018

The exclusion criteria were any patient that did not meet the stated inclusion criteria. Patients that died on scene or enroute to hospital were not included. It was hypothesized that the epidemiological characteristics of adult patients who sustained severe TBI in the Khomas region differ from those who sustained injuries in the Otjozondjupa region in terms of the outcome given the time taken to definitive care by patients from the Otjozondjupa region.

Data collection

Data was collected from the MVA Fund case management google spreadsheet and SIEBEL system (MVA Fund in-house production system). Patients who sustained a severe TBI were extracted from the case management google spreadsheet and the MVA Fund's SIEBEL system was used to determine the costs, ages, and location of MVCs. Patients whose diagnosis was not clearly stipulated as severe TBI on the case management spreadsheet were excluded as the severity of the injury could not be established.

Data analysis

Data were analysed using SPSS statistical package, Version 25 [18]. Descriptive statistics were used to report counts, percentages, mean and standard deviation and presented in tables. Pearson chi-square test for independence was done to determine whether a relationship existed between the dependent variable and independent variables. A p-value of 0.05 was deemed to be statistically significant.

Ethical approval

The study received ethical approval from the Ethics Committees of the Namibian University of Science and Technology and the Ministry of Health and Social Services of Namibia. In addition, written permission to conduct research was granted by the MVA Fund. To respect patient confidentiality and anonymity, no patient identifiable data was extracted.

Results

During the study period, a total of 20 095 crashes were recorded by the MVA Fund of Namibia in which 33 099 occupants were injured. In the Khomas region, 7725 (38.4%) crashes occurred with 8869 (26.8%) injuries while 1848 (9.2%) crashes occurred in the Otjozondjupa region with 4372 (13.2%) injuries. A total of 352 TBIs were recorded. This is however not specific to severe TBIs.

Table 1
Patient characteristics per region.

Characteristics	Khomas Region (*n* = 65) n (%)	Otjozondjupa Region (*n* = 22) n (%)	Total n (%)
Gender:			
Male	58 (89.2%)	20 (90.9%)	78 (89.7%)
Female	7 (10.8%)	2 (9.1%)	9 (10.3%)
Age Groups:			
18-28 Years	25 (38.5%)	7 (31.8%)	32 (36.8%)
29-39 Years	20 (30.8%)	13 (59.1%)	33 (37.9%)
40-50 Years	11 (16.9%)	-	11 (12.6%)
51-61 Years	8 (12.3%)	2 (9.1%)	10 (11.5%)
>61 Years	1 (1.5%)	-	1 (1.2%)
Healthcare Facilities:			
Public Hospital:			
Katutura State Hospital	34 (52.3%)	5 (22.7%)	39 (44.8%)
Windhoek Central State Hospital	4 (6.2%)	-	4 (4.6%)
Okahandja District Hospital	-	5 (22.7%)	5 (5.7%)
Otjiwarongo District Hospital	-	3 (13.6%)	3 (3.4%)
Grootfontein District Hospital	-	1 (4.5%)	1 (1.1%)
Total	**38 (58.5%)**	**14 (63.6%)**	**52 (59.8%)**
Private Hospital:			
Mediclinic Windhoek	16 (24.6%)	5 (22.7%)	21 (24.1%)
Roman Catholic Hospital	6 (9.2%)	2 (9.1%)	8 (9.2%)
Lady Pohamba Private Hospital	4 (6.2%)	1 (4.5%)	5 (5.7%)
Rehoboth St. Mary's Hospital	1 (1.5%)	-	1 (1.1%)
Total	**27 (41.5%)**	**8 (36.4%)**	**35 (40.2%)**

Patient characteristics

Eighty-seven patients met the inclusion criteria, 22 (25.3%) from the Otjozondjupa region and 65 (74.7%) from the Khomas region. The mean age of patients in Khomas and Otjozondjupa regions was 34 (*SD* 12.79) years and 32 (*SD* 8.36) years respectively, while the mean overall age was 34 (*SD* 11.79) years. The age group, 29-39 years ($n = 33$, 37.9%), contained the highest proportion of patients while 74.7% ($n = 65$) of all patients were <40 years. Most patients were male ($n = 78$, 89.7%) while patients were mainly admitted at state healthcare facilities ($n = 52$, 59.8%) situated in the two regions (Table 1).

MVC Characteristics

Most patients in the Khomas region travelled by sedan ($n = 42$, 64.6%) while in the Otjozondjupa region most travelled by pick-up vehicle ($n = 10$, 45.5%). In the Khomas region, pedestrians ($n = 34$, 52.3%) were the most injured while in the Otjozondjupa region, the most common position of an injured occupant was the driver ($n = 11$, 50%) (Table 2).

Patient outcomes

The mortality rate among all included patients ($n = 87$) was 39.1% ($n = 34$). Amongst the male patients, the mortality rate was 37.1% (29/78) and 55.6% (5/9) amongst females (Table 3). The three age groups, 18-28 years (40.6%), 40-50 years (45.5%) and 51-61 years (40.0%), each had a mortality rate of 40.0% or higher while the age group 29-39 years had a 36.4% (12/33) mortality rate. The mortality rate amongst patients with an isolated TBI was 39.6% (19/48) and 38.5% (15/39) in the group of patients with compounding injuries. No statistically significant associations were found between patient outcomes (died or discharged from hospital) and the independent variables (age group, gender, type of MVC, vehicle type, occupant position) and facility (public versus private) for the two regions as well as for the overall data.

Medical cost

The total medical costs for managing the included patients from the Otjozondjupa region was USD 550 173.47 (N$ 8 423 155.86) and USD 1 315 077.00 (N$ 20 133 842.22) for included patients from the Khomas region. This totaled to USD 1 865 251.34 (N$ 28 556 998.08). The average cost per patient in the Otjozondjupa region was USD 25 007.89 (N$ 382 870.72) while the average cost per patient in the Khomas region was USD 20 231.95 (N$ 309 751.42). These costs include ambulance costs up to hospital expenses involved directly in the medical management of the patients and were extracted from invoices submitted to the MVA Fund for payment of services rendered by medical providers and ambulance service providers.

Discussion

To our knowledge, this is the first research to describe the characteristics of adult patients who sustained a severe TBI secondary to an MVC in Namibia. Our study found that in the two Namibian regions, male patients, and patients 40 years or younger more commonly sustained severe TBIs secondary to MVCs. No statistically significant difference were found between the mortality rates of severe TBI patients in the 2 regions.

Characteristics of TBI patients

It is well documented in the literature that males sustain TBIs more commonly than females whether in low or high-resource settings [5,19] and this has been mainly attributed to behavioral factors, amongst others, such as driving under the influence of alcohol & other illicit substances and reckless driving [5,19].

Pedestrians in the African region have been identified as vulnerable road users at high risk of injury and death [20,21]. Similarly, the current study found a high proportion of pedestrians sustaining a severe TBI and this may be indicative of unsafe pedestrian conditions requiring further investigation and interventions to prevent further injury in this class.

Younger persons (20-40 years), similar as suggested in the current study, are the main population to sustain TBIs. Because this group is the economically active population, TBIs can be expected to place a major socioeconomic burden on countries. Additionally, the transport sector is an integral part of modern economies and MVCs cause a negative impact on a country's economy secondary to capital losses and the loss of the labour force [22].

Table 2
MVC characteristics per region.

Characteristics	Khomas Region (*n* = 65) n (%)	Otjozondjupa Region (*n* = 22) n (%)	Total n (%)
Vehicle Type:			
Pick-up	15 (23.1%)	10 (45.5%)	25 (28.7%)
Sedan	42 (64.6%)	6 (27.2%)	48 (55.1%)
Bus	3 (4.6%)	5 (22.7%)	8 (9.2%)
Truck	3 (4.6%)	-	3 (3.4%)
Motorcycle	2 (3.1%)	-	2 (2.3%)
Sport Utility Vehicles (SUV)	-	1 (4.5%)	1 (1.2%)
Type of MVC (as characterized by the Namibian police):			
Rollover	18 (27.7%)	10 (45.4%)	28 (32.2%)
Pedestrian	34 (52.3%)	3 (13.6%)	37 (42.5%)
Head-side	7 (10.8%)	3 (13.6%)	10 (11.5%)
With animal	2 (3.1%)	1 (0.04%)	3 (3.4%)
With fixed object	2 (3.1%)	1 (0.04%)	3 (3.4%)
Motorcycle	2 (3.1%)	-	2 (2.3%)
Fell from moving vehicle	-	1 (0.04%)	1 (1.2%)
Head-on	-	3 (13.6%)	3 (3.4%)
Occupant Position:			
Driver	11 (16.9%)	11 (50%)	22 (25.3%)
Passenger	17 (26.2%)	8 (36.4%)	25 (28.7%)
Pedestrian	34 (52.3%)	3 (13.6%)	37 (42.5%)
Animal driver	1 (1.5%)	-	1 (1.2%)
Motorcyclist	2 (3.1%)	-	2 (2.3%)

Table 3
Mortality rate per age group, gender, and injuries.

	Khomas Region (*n* = 65) Died n (%)	Otjozondjupa Region (*n* = 22) Died n (%)	*Total deaths*
Age groups:			
18-28 years	10/25 (40%)	3/7 (42.9%)	13/32 (40.6%)
29-39 years	8/20 (40%)	4/13 (30.8%)	12/33 (36.4%)
40-50 years	5/11 (45.5%)	-	5/11 (45.5%)
51-61 years	3/8 (37.5%)	1/2 (50%)	4/10 (40.0%)
>61 years	-	-	0/1 (0%)
Total	**26/65 (40.0%)**	**8/22 (36.4%)**	**34/87 (39.1%)**
Gender:			
Male	22/58 (37.9%)	7/20 (35.0%)	29/78 (37.1%)
Female	4/7 (57.1%)	1/2 (50%)	5/9 (55.6%)
Total	**26/65 (40.0%)**	**8/22 (36.4%)**	**34/87 (39.1%)**
Injuries:			
Isolated TBI	15/39 (38.5%)	4/9 (44.4%)	19/48 (39.6%)
Compounding injuries	11/26 (42.3%)	4/13 (30.8%)	15/39 (38.5%)
Total	**26/65 (40.0%)**	**8/22 (36.4%)**	**34/87 (39.1%)**

Mortality

From the data collected, we were unable to determine the mortality period of the patients and for this reason, patient outcomes were described as discharged from hospital or died. The MVA Fund since 2009 has however adopted the WHO definition of road death which is any death occurring immediately or within 30 days as a result of a road crash.

Although no differences were found between patients that sustained an isolated TBI (39.6%) versus those with compounding injuries with a severe TBI (38.5%), evidence suggests TBI severity to be the major determining factor to patient outcomes while compounding injuries do not necessarily have a significant impact [23].

We expected that mortality in the Otjozondjupa would be higher given the increased time to definitive care. This hypothesis was based on the cornerstone of the management of TBI, which is aimed at preventing secondary TBI, making the initial management vital as it can influence patient outcomes [24]. Pakkanen et al.[25] suggests that better patient survival outcomes and better neurological function post-TBI can likely be linked overall to effective pre-hospital care. The Namibian pre-hospital care system is relatively new and still under-developed. In comparison to the rest of the country, the Khomas region has the most developed pre-hospital care services. Services in the Otjozondjupa region are limited with an absence of ambulances in some areas. Finding no difference between the mortality rates of the two regions was therefore not expected due to the limited resources in the Otjozondjupa region and overall time to definitive care.

Our findings did not suggest worse outcomes in any particular age group, however, other literature suggests older patients have poorer outcomes after sustaining TBIs. This is due to the physiological changes that occur with age which predisposes them to injury and resultant worse outcomes [26].

The patients of the current study were admitted and managed at various facilities, some private facilities and others, public facilities. A cross-analysis found no statistically significant difference in the outcome of the patients in regard to whether they were managed at public or private facilities, however, the study sample was small and not powered to detect these differences.

It is evident that further in-depth studies are required to fully understand and describe the extent of the TBI and more generally the trauma burden in Namibia. Investigating the impact of distance and time to definitive care as well as the impact of pre-hospital interventions on the outcome of severe TBI patients, may assist in focusing attention on the need for emergency care development in the country. Additionally, trauma registries need to be established in Namibia in order to streamline trauma research and care in the country.

Medical costs

International studies suggest that the financial burden associated with TBIs in high-resource settings are significant [3,27]. Less is known about the economic burden in Africa, however, the impact of TBIs in low-resource settings is believed to be far exceeding those in high-resource settings [1]. Modelling suggests that the estimated total number of TBIs in Africa in 2050 will be almost 6 million cases with the highest occurrence in males between 15 and 34 years and the lowest amount in Southern Africa [28]. Although the medical cost from the current study (USD 1 865 251.34/N$ 28 556 998.08) might seem less significant, it only represents data from two Namibian regions, adults with severe MVC-related TBIs and excludes costs such as rehabilitation, medical benefits, injury grants, etc. Webster et al. [29] reported unpublished data from a 2009 internal audit at Groote Schuur Hospital in Cape Town, South Africa, finding that the direct costs of managing 654 TBI (moderate-severe) patients at this hospital were USD 1 139 696.67 (N$ 17 448 756.00) [29]. Although the South African figure is from 4 years prior to our study, the direct cost (USD 1 315 077.00/N$ 20 133 842.22) of managing the 65 severe TBI patients from the Khomas region alone exceeded that of managing patients in the South African study. This may be indicative of the high costs involved in managing severe TBI patients in the country. The true cost of TBIs in Namibia is likely much higher, potentially constraining the growth of the country. Dedicated studies evaluating and describing the financial burden and economic impact of TBIs of any cause in Namibia are vital.

The retrospective nature of the current study may present various potential limitations like selection and information bias, issues with missing data and uncertainty about generalisability. The convenience sampling method employed may have subjected the study findings to selection bias. The study sample was small, affecting the ability to detect a statistically significant difference in patient outcomes even if they existed and raises concerns with generalisability.

In addition, MVC-related TBIs in younger victims, mild and moderate MVC-related TBIs and TBIs secondary to causes other than MVCs was not described. Patients who sustained severe TBIs but were not captured on the tool used for data collection and those that died on scenes or prior to arrival at hospital were not included in the study, potentially resulting in underreporting. The classification of the TBI severity was at the discretion of the medical doctor and the criteria used is not known further restricting the generalisability of the study findings. Although anecdotal information, local neurosurgeons suggest that the Glasgow Coma Scale (GCS) and the Marshall score are the 2 systems used to classify the TBI severity in Namibia.

Furthermore, the data was collected only from the MVA Fund thus further limiting the study, however, data capturing systems remain under-developed in the country which greatly hinders the conduction of research. Despite these limitations, we hope that this study highlights the need for further research aimed at describing the epidemiology of injuries in Namibia and aid in the development of more rigorous data capturing systems to facilitate research.

Conclusion

The study, to our knowledge, was the first to describe the epidemiology of TBIs in Namibia. Young individuals who are the economically active population sustain more TBIs with potentially greater resultant socio-economic burdens that ensue post-injury. The two regions studied, carried a huge medical cost for managing these patients which is only a fraction of the total cost of managing TBI patients.

A larger focus needs to be placed on trauma research in Namibia, particularly related to MVCs to curb the TBI issue and inform healthcare planning. This research is a step forward in understanding severe TBI's from MVC's in Namibia and can inform healthcare planning, particularly in the pre-hospital setting. More research is however required to study the effect of pre-hospital care, on the outcome of TBI patients in Namibia, as the literature suggests that adequate pre-hospital care may lead to improved outcomes in TBI patients.

Dissemination of results

Results from this study were submitted and presented to the academic staff of the Namibia University of Science and Technology (NUST). The research report was also shared with the MVA Fund Chief: Human Capital.

Author's Contributions

Authors contributed as follows to the conception or design of the work; the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content: PA contributed 50% and AL contributed 50%. All authors approved the version to be published and agreed to be accountable for all aspects of the work.

Declaration of Competing Interest

The corresponding author is an employee of the Motor Vehicle Accident Fund of Namibia. The authors declared no further conflict of interest.

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