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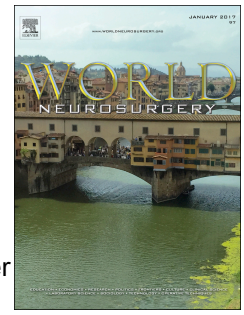

Epidemiology and Pattern of Traumatic Brain Injuries at Annapurna Neurological Institute & Allied Sciences, Kathmandu, Nepal

Nicola Newall, Sharad Gajuryal, Sangita Bidari, Ashmita Karki, Prashmita Karki, Peter Bodkin, Basant Pant

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Authors and Affiliation: Nicola Newall[1,2], Sharad Gajuryal[2], Sangita Bidari[2], Ashmita Karki[2], Prashmita Karki[2], Peter Bodkin[1], Basant Pant[2]

Affiliation and Address
[1] Department of Neurosurgery, Aberdeen Royal Infirmary, Aberdeen, Scotland, United Kingdom
[2] Department of Neurosurgery, Annapurna Neurological Institute & Allied Sciences, Kathmandu, Nepal

Corresponding Author: Nicola Newall
Email: nicola.newall91@gmail.com
Address: 23 Albert Den, Aberdeen, AB25 1SY

Authors: Nicola Newall: BSc (Honours), MBChB (Year 5)
Sharad Gajuryal: MBBS MDHA
Sangita Bidari: BSc
Ashmita Karki: BSc
Prashmita Karki: BSc
Peter Bodkin: FRCS, MBChB
Basant Pant: M.D. PhD

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Abbreviations:

ANIAS: Annapurna Neurological Institute & Allied Sciences
CT: Computed Tomography
DAI: Diffuse Axonal Injury
DSA: Digital Subtraction Angiography
GCS: Glasgow Come Scale
GOS: Glasgow Outcome Scale
LMIC: Low to middle income country
MRI: Magnetic Resonance Imaging
RTA: Road Traffic Accident
SAH: Subarachnoid Haemorrhage
TBI: Traumatic Brain Injury
USS: Ultrasound Scan
WHO: World Health Organization

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Abstract

Background: Traumatic brain injury (TBI) constitutes a major health and socioeconomic problem worldwide. It represents the greatest contribution to death and disability amongst all trauma related injuries globally. TBIs are a leading cause of death and disability in Nepal, despite improvements in safety regulations and implementation of strict drunk driving laws. We describe the epidemiology of patients with TBI following admission to our hospital. We discuss the implementation of specific strategies to reduce its incidence.

Methods: A retrospective cross-sectional study of patients presenting to Annapurna Neurological Institute & Allied Sciences (ANIAS), Kathmandu, with a TBI between September 2018 to September 2019.

Results: 167 patients presented with a TBI. The most common age groups were under 15 years old and 15-25 years old, and the majority were male (73%). The commonest cause of TBI was road traffic accidents (RTA) (59%). Drivers riding motorcycles were the predominant mechanism of RTA (38%). Helmet use was seen in 57% of patients riding 2-wheelers. Alcohol consumption was reported in 22% of all patients. Skull fractures were the most common diagnosis. Most patients were managed conservatively (84%).

Conclusion: TBI should be recognised as an important public health problem in Nepal. TBI is responsible for a considerable number of neurosurgical admissions to ANIAS. Our study showed patients most vulnerable to TBI are young males under 25 years old. The implementation of stricter traffic rules and regulations, helmet law enforcement and public education programs may be helpful in decreasing the number of TBI.

Introduction

Traumatic brain injury (TBI) is an acquired form of brain injury and is defined as ‘an alteration of brain function or other evidence of pathology, caused by an external force.[1] TBI constitutes a major health and socioeconomic problem worldwide. It represents the greatest contribution to death and disability amongst all trauma related injuries globally.[2] When compared with the general population, TBIs are associated with increased mortality and decreased life expectancy.[3,4]

It is estimated that more than 69 million people each year have a TBI, and approximately half the world’s population are likely to have one or more TBI over the course of their lifetime.[5] The World Health Organisation (WHO) estimates that 90% of the deaths due to TBI occur in low- to middle- income countries (LMIC), which is where 85% of the population live.[6] Globally, the incidence of TBI in LMICs is increasing sharply.[7] Despite this, there remains a lack of research into its epidemiology. This is particularly true for Nepal, where studies on TBI are scarce.

In Nepal, TBI represents one of the leading causes of death and disability, where it is estimated the incidence is 382 per 100,000, compared with a global average of 369 per 100,000.[8] However, its incidence is likely an underestimate due to lack of motorable roads, difficult geographical location and unavailability of nearby trained personnel, meaning many patients fail to present to hospital.

The majority of our knowledge on the epidemiology of TBI in Nepal comes from descriptive case series or cross-sectional single centre studies. Amongst these injuries, RTAs and falls represent the leading cause of TBI. In recent years there has been a gradual increase in RTA related TBI due to the surge in motorization and urbanization in the country.[9] According to a hospital based study, amongst the 1056 patients admitted over a 1 year period with a history of TBI in eastern Nepal, 76% were due to RTA. [10]

In recent years, the government has addressed road safety in an attempt to reduce the burden of RTA. They have focused on improving the road infrastructure, implementing stricter traffic rules and regulations and introducing laws enforcing the use of helmets and prohibiting drunk driving. Although these measures have reduced the number and impact of RTAs, there are, at present, lack of policies and appropriate interventions to specifically curtail and prevent TBI.

Given the lack of data in the literature and the growing incidence of TBI, this study aims to analyse the epidemiology of TBI by examining a prospectively populated database of all patients presenting to one of the main neurosurgical hospitals in Kathmandu, Annapurna Neurological Institute & Allied Sciences (ANIAS). The results from this study will also help in guiding the implementation of appropriate interventions and in developing policy to reduce the incidence of TBI in Nepal.

Methods

Setting

This study was conducted at ANIAS, Kathmandu, Nepal. ANIAS, which was established in 2009, is a 55 bed multi-speciality private hospital and one of the major neurosurgical centres in Kathmandu. The neurosurgery department consists of 8 consultant neurosurgeons, 6 residents and several nurses and medical officers. The hospital itself has advanced neuroimaging services including computed tomography (CT), magnetic resonance imaging (MRI), digital subtraction angiography (DSA) and ultrasound scanning (USS). There are 3 operating theatres which run adjacent to each other. The operating theatres are well equipped with an operative microscope, neuro-navigation technology and intra-operative imaging. On average the hospital performs 125 neurosurgical operations per month, equating to 1500 per year.

Study design and data collection

In accordance with the Nepal Health Research Council (NHRC), ethical approval was obtained from the Institutional Review Committee (IRC) for this study. This is a retrospective cross-sectional study on all patients who presented to ANIAS with a history of TBI between 1st September 2018 and 1st September 2019. This sample includes patients living in Kathmandu as well as patients living in remote districts.

Patient lists were generated by searching the relevant ICD-10 definitions of TBI in the electronic patient records. Demographics of patients, mechanism and time of injury, type of road, helmet and alcohol status, Glasgow Coma Scale score (GCS) at presentation, CT diagnosis, intervention, Glasgow Outcome Scale (GOS) score on discharge and length of hospitalization were collected. Sources of data included referral letters and imaging reports

from primary hospitals, emergency department records, inpatient notes, discharge summaries and clinic follow up notes. Data was recorded and analysed on a *Microsoft Excel* spreadsheet.

The sample size consisted of 167 patients. In some patients, (Venturini) (Venturini) data for certain variables was unavailable. For each variable, the sample size and missing data are reported, and the results are presented using descriptive statistics.

Results

The age of patients ranged from 8 months to 92 years. The mean age of patients was 32.1 years (SD +/- 21.32). The most common age group sustaining a TBI were under15 years old (22%, n=37) and 15-25 years (22%, n=37) (Figure 1). There was a clear difference in the patient gender, where 73% (n=122) were male and 27% (n=45) were female.

RTAs were the commonest mechanism of injury (59%, n=99), followed by falls (32%, n=53) and physical assault (9%, n=15) (Figure 2). Of the RTAs, drivers riding a motorcycle was the commonest category (38%, n=38). Vehicle-pedestrian collisions accounted for the second most common RTA (n=31). RTAs were most common in 15-25 years (29%, n=28). This was followed by the 26-35 years category (27%, n=26) (Figure 3).

Of the motorcycle accidents, 43% (n= 21) of patients were not wearing a helmet at the time of injury, all of which were the passengers. Thirteen of the 62 patients, however, had missing data regarding the use of a helmet (Table 1).

Pitch roads were responsible for the majority of RTAs (46%, n=44) (Figure 4). Gravel accounted for the next commonest road condition resulting in 31 injuries (32%). The fewest accidents occurred on slippery terrain (20%, n=19) and on the highway (2%, n=2). Data on road condition at the time of RTA was missing for 3 patients.

Falls represented a large number of TBI (32%). Of the 53 cases, 39 (74%) were falls from a height, and 14 (26%) were falling at ground level due to walking on slippery terrain, tripping or from patients under the influence of alcohol. Falls were most common in under 15 years old (n=22) (Figure 3). Those aged 46-55 and >65 years were the next commonest group.

Of all TBIs, 22% (n= 34) of patients were under the influence of alcohol (Table 1). Alcohol consumption was most common in 26-35 years (n=12) and in RTAs (n=22) (Figure 5). Data, however, was missing for 7 of our patients. Most TBIs occurred in the evening between 5pm – 9pm (n=59). This was followed by the morning between 5am- 12pm (n=47) (Figure 6). The least amount of injuries occurred during the night between 9pm- 5am (n=11) and in the afternoon (12pm-5pm) (21%, n=32). We are, however, missing data for 18 patients.

Following injury, most patients presented with a minor head injury of GCS 13-15 (84%, n=141) (Table 1). CT findings were available for 157 of 167 patients. Many patients presented with more than one diagnosis on CT head (n=212). The most common diagnosis was skull fracture (29%, n=61), followed closely by contusions (22%, n=47) (Table 2). Traumatic subarachnoid haemorrhage (18%, n=38) and subdural haematoma (16%, n=33) were also common findings on CT. Other pathologies included extradural haematoma (12%, n=25), diffuse axonal injury (3%, n=6) and intracerebral haemorrhage (<1%, n=2).

Conservative management was the most common treatment following TBI (84%, n=140). Operative management was undertaken in 16% (n=27) of cases. Elevation of depressed fracture was the most common surgical intervention at ANIAS and accounted for 30% (n=8) of all surgical procedures. This was closely followed by craniotomy and evacuation of clot (26%, n=7) and decompressive craniotomy (15%, n=4). Ten patients discharged against medical advice (DAMA). These patients were initially treated conservatively but declined imaging and further medical intervention.

GOS at discharge was available for 157 of 167 patients. Eighty-four percent of patients were a score of 5 and 7% were 3 or 4 at discharge (Table 1). Four percent of patients had a GOS of 1: 1 patient died with a diagnosis of DAI, 1 with DAI along with contusions and a depressed skull fracture, 1 with an extradural haematoma, 1 with a subdural haematoma and contusions and 2 with an isolated depressed skull fracture.

Discussion

Understanding the epidemiology of TBI is fundamental towards shaping public health policy and implementing preventative strategies. Studies describing the epidemiology in Nepal are limited. We conducted a cross-sectional study of all patients presenting to ANIAS, Kathmandu, Nepal, with a history of TBI. Our principal objective was to describe the epidemiology and clinical characteristics of TBI at our hospital and make suggestions of specific strategies to reduce its incidence.

In our study, we found that the majority of patients presenting to the hospital with a TBI were under 15 years old and between the age of 15-25 years old. This pattern of high rates of TBI in childhood and late adolescence has been shown in many population-based studies in other developing countries. [11-13] In contrast, recent studies from high income countries have shown a shift in the population affected by TBI towards older age groups.[14,15] The high incidence of injury in the younger age groups in our study may partly be explained by the large youth population in Nepal where it is estimated that 51% of the population is under 25 years old. [16] As this is the economically active group, this can have a substantial effect on the economy due to the loss of productive life years. However, it's difficult to know the exact economic impact in Nepal as the majority of TBI epidemiologic studies do not provide information regarding the financial impact or the loss of productivity.

Similar to much of the literature from both HIC and LMICs, males accounted for the majority of all TBI.[12,17,18] The predominance of head injuries amongst men can be explained by the different roles between genders in Nepal. Anecdotally, males are more likely to drive, ride bicycles and be involved in hazardous activities. In addition, males are prioritised when it comes to accessing health care, with females having 2.6 times less access to health services than males.[19] Therefore, the results from our study may not be representative of the true incidence of females sustaining a TBI.

Nepal suffers a heavy burden of RTAs. RTAs rank 11th among the leading causes of disability-adjusted life years and 12th among the leading causes of premature deaths in the country.[20] In recent years, there has been a surge in motorization and urbanisation in the country where around 40,000 new vehicles have been added to the roads each year.[21] Hence, among our patient population, RTAs were the predominant cause of TBI. Of all RTAs, motorcycle accidents were the leading mechanism of injury. Similar to its neighbouring

countries, motorcycles are now the commonest mode of transport in Nepal due to their low cost and the predominance of narrow roads and heavy congestion. [22,23]

Although the majority of RTAs were as a result of motorcycle accidents, vehicle-pedestrian collisions represented the second most common mechanism of RTA. The increase in motorization and lack of well-constructed roads, footpaths and absence of a proper system for crossing roads in Nepal are factors putting pedestrians at risk. Public awareness campaigns and infrastructure measures to separate road users and pedestrians may be of benefit to protect individuals and reduce the number of RTAs.

Of the motorbike accidents, 43% of patients were wearing a helmet at the time of injury. Interestingly, 100% of the helmeted patients were the drivers. This result may be explained by the helmet legislation which states that it is mandatory for drivers to wear a helmet. For those non-compliant, high penalties exist. In Nepal, these fines can be up to 100 USD. Since the introduction of the helmet legislation, there has been an increased use of helmets amongst drivers of 2-wheelers. Although the results of helmet legislation in Nepal have been promising, other countries have struggled to achieve long-term compliance. One factor contributing to the reduced helmet usage is the low penalties for breaking the law. [22]

Helmet legislation in Nepal does not yet apply to the passengers of 2-wheelers. Although the outcome in unhelmeted patients in our study was favourable, given the high incidence of RTAs and increased likelihood of passengers to sustain injury, the legislation needs to be challenged to include a provision making the use of helmets mandatory for all passengers.

With respect to alcohol use, 22% of patients sustaining a TBI from RTA were under the influence of alcohol at the time of injury. Drunk driving is a well-documented problem in Nepal where a previous study examining motorbike accidents in Kathmandu reported that 21% of victims were under the influence of alcohol.[24] As a result of this growing problem, the Nepal government introduced a strict drunk driving policy in 2012. The results from this policy were promising, where two years after its introduction, the number of RTAs and injuries decreased by 28% and 60%, respectively.[25] More recently, the Nepal government adopted a National Alcohol Regulation and Control Policy to reduce the availability of alcohol and further address its burden.

Despite the strict enforcement laws, we report the number of drunk drivers in our study to be rather high. Whilst the majority of patients had a good outcome at discharge, 3 patients were left with minor neurological deficits and there were 3 fatalities.

Several studies in Nepal have reported on the high incidence of paediatric head injury as a result of falls.[26,27] In our study, falls were most common under 15 years old, accounting for the largest cause of injury in this age group. The predominant mechanism was falling from a height. Although the reason for this is not clear, the lack of safety measures in apartments is a plausible factor. Many of the apartments have low balconies and windows without barriers and combined with the lack of parental supervision, children climb over the balconies, falling multiple storey's. Despite a large number of paediatric head injuries and recommendations to the government for the implementation of safety barriers, no preventative measures have yet been instituted to curtail this problem.

Abusive head trauma (AHT) is a significant cause of morbidity and mortality in the paediatric population. The incidence of AHT is reported to be 20-30 per 100,000 children.[28] Several studies analysing the epidemiology of paediatric head injury have reported AHT as a

common mechanism of injury.[29,30] In our study, we had no documented cases of AHT. However, given many of these cases are underdiagnosed, it is possible AHT was a cause of TBI in some of our paediatric group.

Most TBIs occurred during Kathmandu's evening rush hour between 5pm – 9pm (40%). A large proportion of the RTA related TBI occurred on pitch and gravel roads, accounting for 46% and 32% of injuries, respectively. In Nepal, the road condition and infrastructure is poor, with the volumes of vehicles increasing faster than the improvements in infrastructure. The majority of the roads are narrow and of the 29157 kilometres available road network in Nepal, only 12305 kilometres (42.20 %) road was black topped and the rest was gravel or earthen.[31]

Skull fractures (29%) were the most common diagnosis followed by contusions (22%) and subarachnoid haemorrhage (18%). Previous studies in Nepal have reported similar findings following a TBI.[32,33] However, much like in our study, these papers did not specify the diagnosis in relation to the mechanism of injury. It could be hypothesised that the increased incidence of skull fractures, contusions and subarachnoid haemorrhage is related to the mechanism of injury, given that motorcycle accidents accounted for the majority of TBI admissions. Although helmets are protective against direct impact, they do not protect against the shearing forces which results in SAH and contusions. [34] Therefore, further analysis is required to record the exact head injury type to the mechanism of injury. This would help to identify any relationship between the diagnosis and the mechanism of injury and ascertain the effectiveness of helmets at reducing certain head injuries.

Only six deaths were recorded in our study; therefore, the data set is too small to record any conclusions about this group. Overall, most patients had a good clinical outcome following TBI**.** Eighty four percent of patients who were admitted to our hospital had a mild GCS (84%), and 92% of patients were discharged with a GOS of 4 or 5. It is reported that outcomes following TBI are influenced by prompt treatment which focuses on the prevention of secondary brain injury.[35] Although the majority of patients in our study received primary treatment prior to presenting to ANIAS, we however did not consider the time taken to present to primary care nor the distance to a primary care hospital. Research to evaluate these factors would help us understand any relationship between the time to primary treatment and the clinical outcome.

Limitations

Limitations of this study were that the exact injury type in relation to the mechanism of injury was not recorded. Additionally, data for certain variables such as alcohol use, helmet use and road type, were also missing for a number of patients. Only patients who had a sufficient data set were included in our study. Similarly, those who presented to the outpatient's clinic and who were not admitted to hospital were not included. Obtaining data for many of the variables listed was often difficult due to lack of adequate data storage and the loss of patient follow up. In the future, it would be beneficial to conduct research over a longer time frame which would increase the sample size and enable us to see any changes in epidemiology and clinical outcomes.

Conclusion

Our study provides an insight into the epidemiology and pattern of TBI in ANIAS. It highlights that TBIs, particularly as a result of motorcycle accidents and fall injuries, are a public health concern in Nepal. The high incidence of TBI in both the young (15-25 years) and paediatric (<15 years) population should be highlighted. TBI has the potential to result in long-term disability, affecting cognition, behaviour and motor control. As the economically active population are largely affected, this has a substantial economic impact on the community due to the loss of years of productive life.

Given the high incidence of RTAs, emphasis should be placed on implementing stricter traffic rules and regulations and on improving the road infrastructure to accommodate the surge in motorization. Although efforts have been directed towards improving road safety by introducing a drunk driving and alcohol regulation policy, this has been met with poor compliance. The helmet legislation law has shown promising results, however, this does not yet extend to passengers of 2-wheelers. Consideration of a helmet policy for passengers is necessary to encourage road safety and reduce the impact of a TBI.

Another important finding from our study was the identification of a large number of fall injuries in the paediatric population. Due to this high prevalence, further research is necessary to establish preventative measures to address this problem. Public education designed to improve adult supervision of children is one area which can be explored to help reduce these preventable accidents.

Raising the awareness of TBI and educating the public on prevention methods would enable patients to understand the importance of seeking early medical care and taking specific measures to reduce the chance of head injury occurring. This is an important future direction towards reducing the health and economic burden of TBI in Nepal and engaging the community in public health.

References

1. Menon DK, Schwab K, Wright DW, Maas AI. Demographics and clinical assessment working group of the international and interagency initiative toward common data elements for research on traumatic brain injury and psychological health. Position statement: definition of traumatic brain injury. Arch Phys Med Rehabil. 2010;91(11):1637-40. https://doi.org/10.1016/j.apmr.2010.05.017

2. Maas AI, Stocchetti N, Bullock R. Moderate and severe traumatic brain injury in adults. The Lancet Neurology. 2008;7(8):728-41. https://doi.org/10.1016/S1474-4422(08)70164-9

3. Brooks JC, Strauss DJ, Shavelle RM, Paculdo DR, Hammond FM, Harrison-Felix CL. Long-term disability and survival in traumatic brain injury: results from the National Institute on Disability and Rehabilitation Research Model Systems. Arch Phys Med Rehabil 2013; 94: 2203–09. https://doi.org/10.1016/j.apmr.2013.07.005

4. Brooks JC, Shavelle RM, Strauss DJ, Hammond FM, Harrison-Felix CL. Long-term survival after traumatic brain injury part ii: life expectancy. Arch Phys Med Rehabil 2015; 96: 1000–05. https://doi.org/10.1016/j.apmr.2015.02.002

5. Dewan MC, Rattani A, Gupta S, Baticulon RE, Hung YC, Punchak M, Agrawal A, Adeleye AO, Shrime MG, Rubiano AM, Rosenfeld JV. Estimating the global incidence of traumatic brain injury. Journal of neurosurgery. 2018;1:1-8. https://doi.org/10.3171/2017.10.JNS17352

6. WHO. Cause-specific mortality: estimates for 2015. Avaliable from: http://www.who.int/healthinfo/global_burden_disease/estimates/en/index1.html: World Health Organisation; 2015. Accessed 1st October 2019

7. Hyder AA, Wunderlich CA, Puvanachandra P, Gururaj G, Kobusingye OC. The impact of traumatic brain injuries: a global perspective. NeuroRehabilitation. 2007;22(5):341-53. https://doi.org/10.3233/NRE-2007-22502

8. James SL, Theadom A, Ellenbogen RG, Bannick MS, Montjoy-Venning W, Lucchesi LR, Abbasi N, Abdulkader R, Abraha HN, Adsuar JC, Afarideh M. Global, regional, and national burden of traumatic brain injury and spinal cord injury, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. The Lancet Neurology. 2019;18(1):56-87. https://doi.org/10.1016/S1474-4422(18)30415-0

9. Karkee R, Lee AH. Epidemiology of road traffic injuries in Nepal, 2001–2013: systematic review and secondary data analysis. BMJ open. 2016;6(4):e010757. http://dx.doi.org/10.1136/bmjopen-2015-010757

10. Kafle P, Khanal B, Yadav DK, Poudel D, Karki T, Cherian I. Head Injury in Nepal: An Institutional Based Prospective Study on Clinical Profile, Management and Early Outcome of Traumatic Brain Injury in Eastern Part of Nepal. Birat Journal of Health Sciences. 2019;4(2):750-4. https://doi.org/10.3126/bjhs.v4i2.25459

11. Shekhar C, Gupta LN, Premsagar IC, Sinha M, Kishore J. An epidemiological study of traumatic brain injury cases in a trauma centre of New Delhi (India). Journal of emergencies, trauma, and shock. 2015;8(3):131. https://doi.org/10.4103/0974-2700.160700

12. Peeters S, Blaine C, Vycheth I, Nang S, Vuthy D, Park KB. Epidemiology of traumatic brain injuries at a major government hospital in Cambodia. World neurosurgery. 2017 ;97:580-9. https://doi.org/10.1016/j.wneu.2016.09.127

13. Adeleye AO, Olowookere KG, Olayemi OO. Clinicoepidemiological profiles and outcomes during first hospital admission of head injury patients in Ikeja, Nigeria. Neuroepidemiology. 2009;32(2):136-41. https://doi.org/10.1159/000182821

14. Lawrence T, Helmy A, Bouamra O, Woodford M, Lecky F, Hutchinson PJ. Traumatic brain injury in England and Wales: prospective audit of epidemiology, complications and standardised mortality. BMJ open. 2016; 6(11). http://dx.doi.org/10.1136/bmjopen-2016-012197

15. Roozenbeek B, Maas AI, Menon DK. Changing patterns in the epidemiology of traumatic brain injury. Nature Reviews Neurology. 2013;9(4):231. https://doi.org/10.1038/nrneurol.2013.22

16. Nepal UNFPA. Population Situation Analysis of Nepal. https://nepal.unfpa.org/sites/default/files/pub-pdf/Nepal%20Population%20Situation%20Analysis.pdf. Accessed 22nd October 2019.

17. Peeters W, van den Brande R, Polinder S, Brazinova A, Steyerberg EW, Lingsma HF, Maas AI. Epidemiology of traumatic brain injury in Europe. Acta neurochirurgica. 2015;157(10):1683-96. https://doi.org/ 10.1007/s00701-015-2512-7)

18. Taylor CA, Bell JM, Breiding MJ, Xu L. Traumatic brain injury–related emergency department visits, hospitalizations, and deaths—United States, 2007 and 2013. MMWR Surveillance Summaries. 2017;66(9):1. https://doi.org/10.15585/mmwr.ss6609a1

19. Garha M. Health care in Nepal: An observational perspective. Journal of Nursing Education and Practice. 2017;7(1). http://dx.doi.org/10.5430/jnep.v7n1p114

20. Karkee R, Lee AH. Epidemiology of road traffic injuries in Nepal, 2001–2013: systematic review and secondary data analysis. BMJ open. 2016;6(4):e010757. http://dx.doi.org/10.1136/bmjopen-2015-010757

21. Joshi SK. Economic and social burden due to injuries and violence in Nepal: a cross-sectional study. Kathmandu University medical journal. 2009;7(4):342-8. http://dx.doi.org/10.2139/ssrn.1518959

22. Venturini S, Still ME, Vycheth I, Nang S, Vuthy D, Park KB. The National Motorcycle Helmet Law at 2 Years: Review of Its Impact on the Epidemiology of Traumatic Brain Injury in a Major Government Hospital in Cambodia. World neurosurgery. 2019;125:320-6. https://doi.org/10.1016/j.wneu.2019.01.255

23. Hoang HT, Pham TL, Vo TT, Nguyen PK, Doran CM, Hill PS. The costs of traumatic brain injury due to motorcycle accidents in Hanoi, Vietnam. Cost Effectiveness and Resource Allocation. 2008;6(1):17. https://doi.org/10.1186/1478-7547-6-17.

24. Gururaj G. The effect of alcohol on incidence, pattern, severity and outcome from traumatic brain injury. Journal of the Indian Medical Association. 2004;102(3):157-60.

25. United Nations Economic and Social Commission for Asia and the Pacific. Kathmandu Do Not Drink and Drive Campaign. https://www.unescap.org/sites/default/files/6.Do%20not%20drink%20%26%20Drive-Nepal.pdf. Accessed 22nd October 2019.

26. Karmacharya BG, Acharya B. Pediatric head injuries in a neurosurgery center of Nepal: an epidemiological perspective. Am J Public Health Res. 2015;3:76-9. doi:10.12691/ajphr-3-4A-16

27. Agrawal A, Agrawal CS, Kumar A, Lewis O, Malla G, Khatiwada R, Rokaya P. Epidemiology and management of paediatric head injury in eastern Nepal. African journal of paediatric surgery. 2008;5(1):15. https://dx.doi.org/10.4103/0189-6725.41630

28. Duhaime AC, Christian CW. Abusive head trauma: evidence, obfuscation, and informed management: JNSPG 75th Anniversary Invited Review Article. Journal of Neurosurgery: Pediatrics. 2019 Nov 1;24(5):481-8.

29. Schrieff LE, Thomas KG, Dollman AK, Rohlwink UK, Figaji AA. Demographic profile of severe traumatic brain injury admissions to Red Cross War Memorial Children's Hospital, 2006-2011. South African Medical Journal. 2013;103(9):616-20.

30. Kelly P, John S, Vincent AL, Reed P. Abusive head trauma and accidental head injury: a 20-year comparative study of referrals to a hospital child protection team. Archives of disease in childhood. 2015 Dec 1;100(12):1123-30.

31. Bhagat SK. Situation of Land Transportation in Nepal. Tribhuvan University Journal. 2017;31(1-2):193-206. https://doi.org/10.3126/tuj.v31i1-2.25355

32. McClennan S, Snider C. Head injuries in Kathmandu, Nepal. McMaster Univ Med J. 2003;1:10-4.

33. Ahmad K, Rauniyar RK, Gupta MK, Ansari S. Spectrum of various patterns of injuries in cranio-cerebral trauma: CT evaluation. Indian Journal of Basic and Applied Medical Research. 2013; 3 (1): 321-327:

34. Lloyd JD. Biomechanical Evaluation of Motorcycle Helmets: Protection against Head and Brain Injuries. J Forensic Biomed. 2017;8(137):2.

35. Greenberg MS, Arredondo N. Handbook of neurosurgery. New York: Thieme; 2001.

Table 1: Patient Characteristics

Characteristic		**Number**
Sex		
Male		122
Female		45
Age		
<15		37
15-25		37
26-35		30
35-45		19
46-55		17
56-65		11
>65		16
Mechanism of Injury		
Fall		53
RTA	Pedestrian-vehicle collision	31
	Motorcycle	38
	Passenger	24
	Car	4
	Bicycle	2
Physical Assault		15
Alcohol Use		
Yes		34
No		126
Missing		7
Helmet Use (n=62)		
Yes		28
No		21
Missing		13
Road Type (n=99)		
Gravel		31
Pitch		44
Slippery		19
Highway		2
Missing		3
GCS at Presentation		
Mild (13-15)		141
Moderate (9-13)		18
Severe (<8)		8
Management		
Conservative		140
Surgical		27

GOS at discharge (n=167)	
5	140
4	4
3	7
2	0
1	6
Missing	10

Table 2: CT findings based on GOS

Diagnosis/ GOS	**5**	**4**	**3**	**2**	**1**
Contusion	41	3	1	0	2
Skull fracture	54	2	2	0	3
Subarachnoid Haemorrhage	36	1	1	0	0
Extradural Haematoma	22	0	2	0	1
Subdural Haematoma	30	0	2	0	1
Intracerebral Haemorrhage	2	0	0	0	0
Diffuse Axonal Injury	0	1	3	0	2
Total	185	7	11	0	9

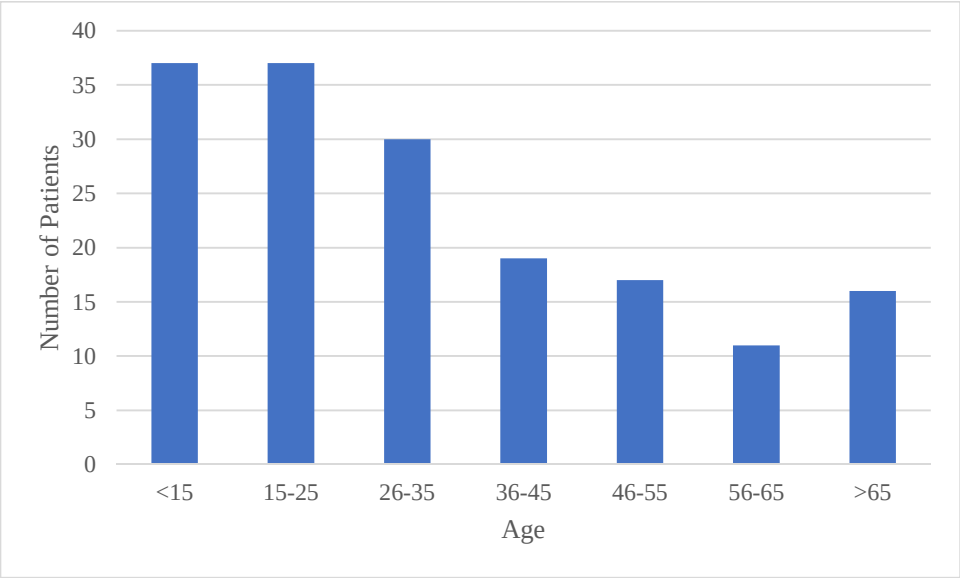

Figure 1: Distribution of TBI presenting to ANIAS based on age (n=167)

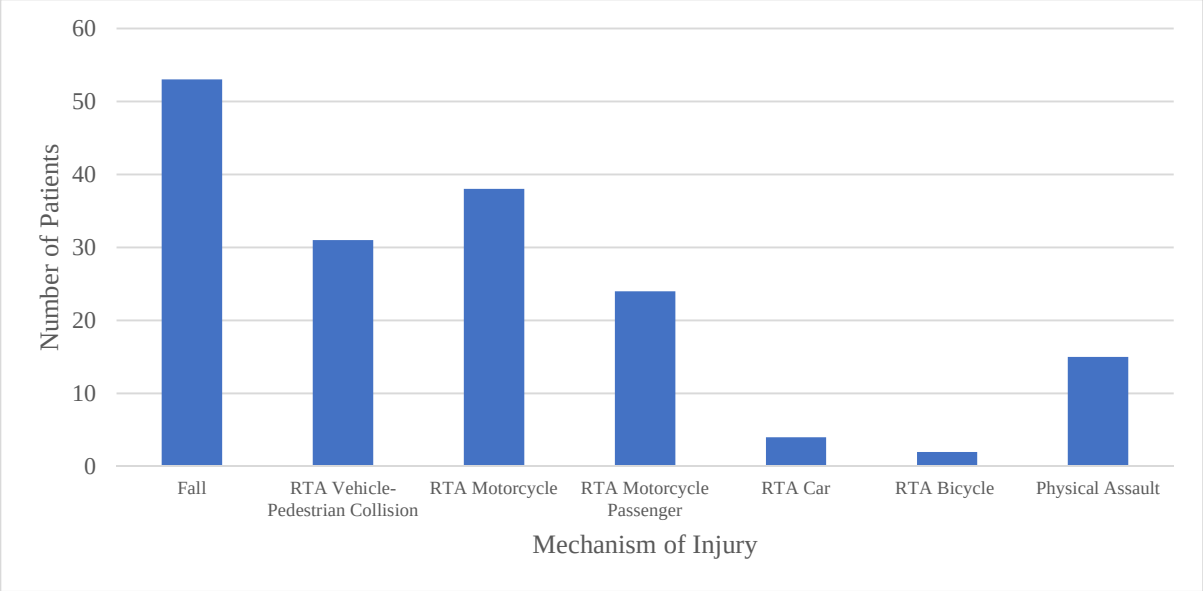

Figure 2: Mechanism of injury demographics at ANIAS (n=167)

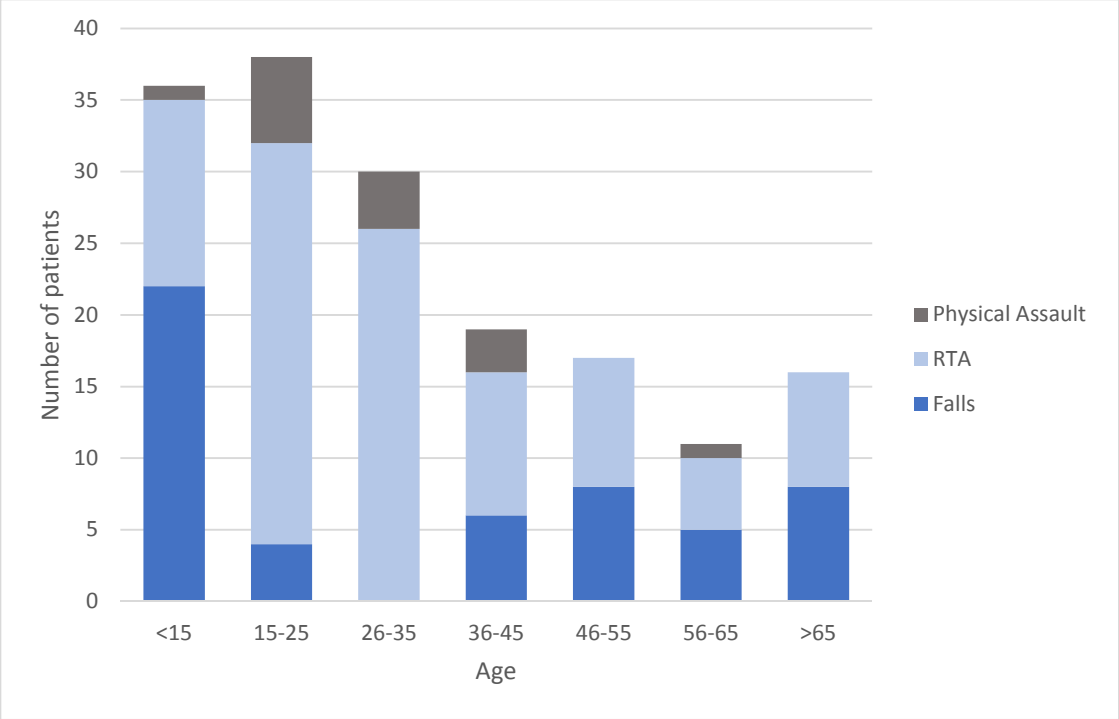

Figure 3: Mechanism of injury according to age of patients presenting to ANIAS (n=167)

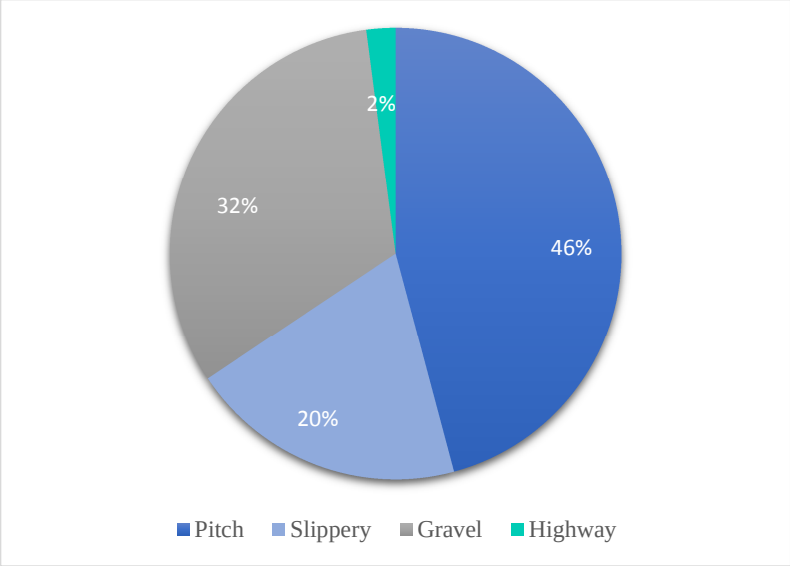

Figure 4: Frequency of RTA in relation to type of road

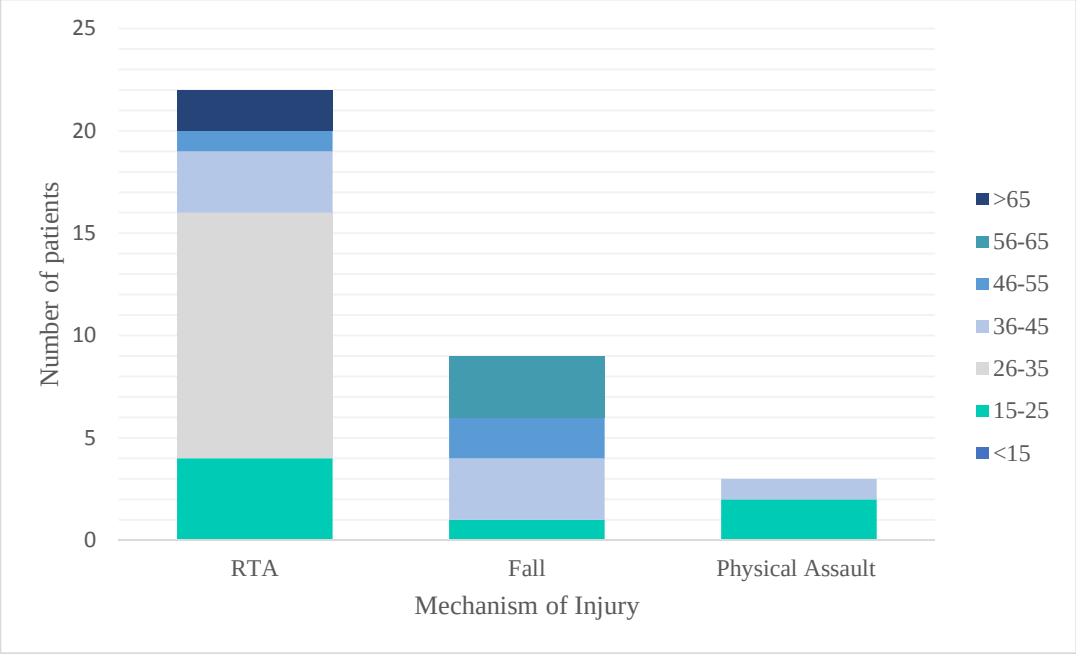

Figure 5: Use of alcohol according to age and mechanism of injury (n=34)

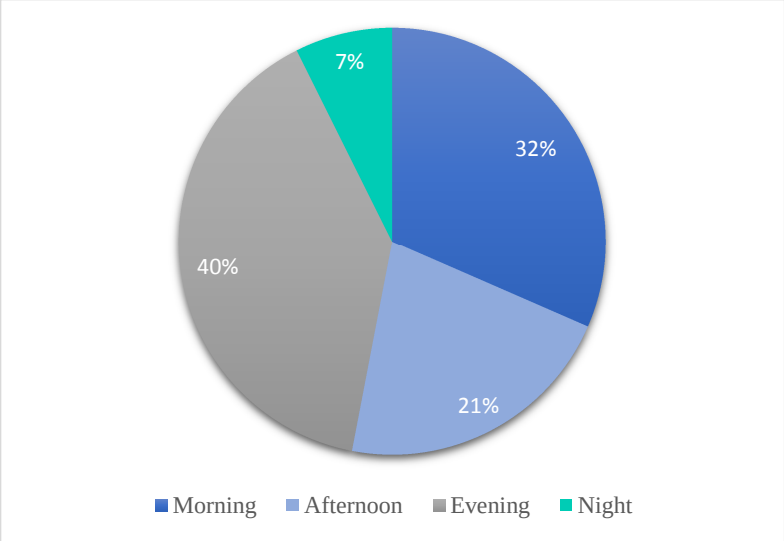

Figure 6: Frequency of TBI according to the time of day

Abbreviations:

ANIAS: Annapurna Neurological Institute & Allied Sciences
CT: Computed Tomography
DAI: Diffuse Axonal Injury
DSA: Digital Subtraction Angiography
GCS: Glasgow Come Scale
GOS: Glasgow Outcome Scale
LMIC: Low to middle income country
MRI: Magnetic Resonance Imaging
RTA: Road Traffic Accident
SAH: Subarachnoid Haemorrhage
TBI: Traumatic Brain Injury
USS: Ultrasound Scan
WHO: World Health Organization

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Nicola Newall: BSc (Honours), MBChB (Year 5)
Sharad Gajuryal: MBBS MDHA
Sangita Bidari: BSc
Ashmita Karki: BSc
Prashmita Karki: BSc
Peter Bodkin: FRCS, MBChB
Basant Pant: M.D. PhD

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