http://www.nzma.org.nz/journal/read-the-journal/all-issues/2010-2019/2015/vol-128-no-1412/6497

ORIGINAL ARTICLE

Traumatic brain injury within Pacific people of New Zealand

Wesley Lagolago, Alice Theadom, Peggy Fairbairn-Dunlop, Shanthi Ameratunga, Anthony Dowell, Kathryn M McPherson, Braden Te Ao, Nicola J Starkey, Valery L Feigin; on behalf of the BIONIC Research Group*

Abstract

Aims Previous research has suggested there are ethnic disparities in the incidence of traumatic brain injury (TBI). This study aimed to: identify the incidence of TBI for Pacific people; describe the injury profile in this population; and determine if there were disparities in healthcare service use.

Methods All TBI cases that occurred within a 1-year period in the Hamilton and Waikato regions of New Zealand were identified using multiple case ascertainment methods as part of a population-based incidence study.

Demographic and injury data from people who self-identified as a Pacific person (N=76) were extracted and compared to New Zealand (NZ) Europeans (N=794). Differences in injury severity, mechanism of injury and acute healthcare service use were explored between the two ethnic groups.

Results The total crude incidence of TBI in Pacific people was 1242 cases per 100,000 person-years, significantly higher than NZ Europeans (842 per 100,000). Peaks in incidence for Pacific people and NZ Europeans were observed between 0–4 and 15–24 years of age, with males at greater risk of injury than females. There were no statistically significant differences in TBI severity, mechanism of injury and acute healthcare use between the two groups.

Conclusion Pacific people are at a significantly higher risk of experiencing a TBI than NZ Europeans and targeted prevention efforts are needed.

Traumatic brain injury (TBI) is becoming a major global health issue.[1] Even mild TBI can impact on a person's quality of life, with many people experiencing persistent and multifaceted symptoms that can impact on community integration, social participation and ability to return to employment.[2]

Evidence from international studies reveals that people from ethnic minority groups have increased incidence and mortality rates following TBI.[3,4] Additionally, ethnic minorities are more likely to have prolonged length of stay in hospital[5] and be discharged home without community services following hospitalisation.[3]

One study has also revealed that ethnic minority groups receive fewer sessions and lower intensity of inpatient physiotherapy, occupational therapy, speech language therapy and psychotherapy in comparison to non-minority groups.[4] Reduced access to health care may be linked to the findings that minority groups have poorer functional outcomes following TBI than non-minority groups.[4]

For Pacific people, a study in the US found that Pacific people had lower incidence of TBI than other ethnic groups[6] with a rate of 239.6 per 100,000 person-years. A previous study based on a national database of hospital discharges in New Zealand (NZ) revealed that the incidence of TBI was higher than reported in the United States (US), with an incidence of 582.6 per 100,000 for males and 217.6 per 100,000 for females.[7]

The observed differences in incidence rates may be due to the different populations and types of TBI severity considered between the two studies as well as potential differences between the US and NZ. In accord with the wider literature on ethnic minority groups, it appears Pacific people sustain TBI at a younger age than other ethnic groups.[3,8,9]

Disparities in health outcome following TBI have been observed, with Asian/Pacific people reported to have a 1.41 risk of mortality in comparison to other ethnic groups.[3] This study also revealed that Asian/Pacific people were more likely to be discharged home than to a rehabilitation centre, although it remains unclear as to why this was the case.[3] It is also difficult to ascertain the extent to which observed disparities reflect disparities specifically for Pacific people, as these this study combined Pacific people with Asian people within the same group.[3,8,9]

The true impact of TBI for Pacific people may also be currently underestimated as incidence rates[10] and healthcare expenditure[11] have previously been limited to those TBI cases who present to hospital or die from their injuries. This approach is problematic as many people who have experienced a TBI choose not to seek medical care[12] and a TBI can be missed if a person presents at hospital with multiple or complex injuries.[13] Population-based prospective methods are needed to capture cases of TBI that occur in the community and who may not present to hospital following injury to ascertain the incidence of TBI for Pacific people.

To ensure resources are effectively allocated to healthcare services, an understanding of whom, and how, people are most affected by TBI in high-risk populations is essential. Pacific people are more likely to be living in low socioeconomic areas; are less likely to be well-educated; and more likely to have poor access to healthcare services.[14] Each of these factors have been identified as predictors of poorer outcome following TBI.[15]

This study therefore aimed to determine the incidence of TBI in Pacific people, using a population-based sample, to describe the mechanisms and contexts of injury, and to explore healthcare use for Pacific people in comparison to NZ Europeans. This will provide insights into how to prevent future injuries and reduce the burden of TBI for Pacific people in NZ.

Methods

Participants—This study draws on data collected as part of a population based TBI incidence study (BIONIC).[16,17] All TBI cases for people across all ages and TBI severities were identified over a one year period. For the purposes of this study, TBI was defined according to the World Health Organization (WHO) criteria which states that TBI is the result of an external physical force causing injury to the brain.[18]

Internal causes of injury such as strokes were excluded. To be included in the study, the TBI needed to have been sustained between 1 March 2010 to 28 February 2011 and the participant needed to be a resident of the Hamilton or Waikato districts.[19] The study area encompassed both urban and rural areas and was of a feasible size to enable collaboration with multiple agencies to identify all TBI cases.

TBI cases were identified from multiples sources including community health services, sports clubs, schools, prisons, residential facilities, General practitioners (GPs) and hospital records before being included in the dataset. TBI participants did not need to have sought medical care following their TBI to be included in the study if there was evidence of the TBI being sustained—e.g. accident record.

Screening of the Accident and Compensation Corporation (ACC) database for people who experienced an injury to the upper half of their body was also conducted. This was to capture TBIs that may have been missed due to being overshadowed by other injuries and those who may not seek medical attention following injury.

Demographic and injury details were collected for all identified TBI cases based on self-report information and details of the injury in the person's medical records. The mechanism of injury was classified according to the International Classification of Diseases (ICD-10) Classification System. TBI severity was based on the Glasgow Coma Scale (score 3–8=severe, 9–12=moderate and mild=13–15) and Post-traumatic Amnesia score (7+ days=severe, 1–6 days moderate and <24 hours=mild). If there was a discrepancy between the GCS and PTA score the more severe category was assigned. As a substantial proportion of TBI cases are classified as mild, mild TBIs were sub-classified according to whether there was an increased risk of complications as proposed by Servadei et al.[20]

After the removal of any duplicate cases, all those with a confirmed TBI were invited to participate in an assessment interview, which explored the healthcare services received and to assess participants everyday functioning. Interviews were conducted within the community, at participant's homes or at a public place where a quiet room was available such as at the university, public library or GP practice by a team of trained research assistants. An indepth description of the BIONIC study methodology has been published elsewhere.[17]

To explore the incidence and injury profile of TBI in Pacific people and to identify ethnic disparities, data relating to Pacific people and NZ European participants was extracted from the BIONIC dataset. People who self-identified as a Pacific person were included in the Pacific people group and those who identified as NZ European were included in the NZ European group. Other European ethnicities such as British, French or Dutch were excluded from the NZ European group to reduce variance within the comparison group.

If participants identified themselves as both NZ European and Pacific people, they were classified for the purpose of analysis as Pacific people. This approach was taken to prevent data being re-analysed across several groups if people identified as having multiple ethnicities and to enable a focus on people who self-identified as Pacific people for this analysis.

The classification of Pacific people included those who identified as Samoan, Tongan, Fijian, Niuean, Cook Islander, and Kiribati. TBI cases from other ethnic groups including Māori, Asian and Latin American were not included in this analysis due to limitations of analysing too diverse a sample of ethnicities with low numbers. Incidence rates for Māori were published as part of the main incidence paper.[16]

Data analysis—TBI incidence rates were calculated utilising 2006 Census data for the city of Hamilton and surrounding Waikato area as the population denominator (Statistics New Zealand, 2006). For each ethnic group the demographic, injury characteristics, risk factors and healthcare seeking following injury were described.

To identify if there were any statistically significant differences between the two ethnic groups, Fisher's exact, Chi-squared and the Mann Whitney U tests were used. Level of significance was set at 0.05. Statistical analyses were conducted using SPSS v20 software.[21]

Results

In total, 870 TBI cases met the study inclusion criteria: 76 identified as Pacific people, and 794 as NZ Europeans. Table 1 summarises the participant characteristics for the total sample and between the two ethnic groups. Males had a greater risk of injury than females for both Pacific people and NZ Europeans. There were no deaths reported in Pacific people and 5 deaths reported for NZ Europeans. Although it appeared that a greater proportion of Pacific people TBI cases were ascertained from Accident and Medical Clinics than NZ Europeans, the difference was not statistically significant.

There were no other significant differences observed between the ethnic groups in demographic or injury characteristics. Whilst there were no significant differences between the two groups for mechanism of injury, the proportion of TBIs due to motor vehicle crashes was lower among Pacific people.

Falls were the most common mechanism of injury for both Pacific people and NZ Europeans. Looking at the context within which TBIs were sustained, the highest proportion of TBIs in Pacific people were sustained during sports and recreational activities, with the majority of injuries (94.0%) classified as being of mild severity.

Table 1. Characteristics of TBI cases across the ethnic groups (*denotes P<0.05)

Variables	Pacific people N (%)	NZ European N (%)	Total N (%)	Statistical significance
Age (median, IQR)	18 (22.0)	22 (29.0)	21 (27.8)	U=35,139, P=0.01*
Gender				
–Female	28 (36.8)	296 (37.3)	324 (37.52	χ^2=0.01, p=0.52
–Male	48 (63.2)	498 (62.7)	546 (62.8)	
Case ascertainment				
–ACC	5 (6.6)	106 (13.4)	111 (12.8)	χ^2=7.55, p=0.11
–Accident/Medical Clinic	14 (18.4)	95 (12.0)	109 (12.5)	
–Hospital/inpatient	50 (65.8)	484 (61.0)	534 (61.3)	
–GP	6 (7.9)	64 (8.1)	70 (8.0)	
–Other e.g. self-referral/support organisation	1 (1.3)	45 (5.7)	46 (5.3)	
TBI severity				
–Mild low risk	12 (15.8)	152 (19.1)	164 (18.9)	χ^2=2.30, p=0.68
–Mild medium risk	24 (31.6)	210 (26.4)	234 (26.9)	
–Mild high risk	36 (47.4)	392 (49.4)	428 (49.2)	
–Moderate	3 (4.3)	19 (2.4)	22 (2.5)	
–Severe	1 (1.3)	21 (2.6)	22 (2.5)	
Prior TBI				
–Yes	19 (25.0)	212 (26.7)	231 (26.6)	χ^2=0.87, p=0.65
–No	33 (43.4)	302 (38)	335 (38.5)	
–Unknown	24 (31.6)	280 (35.3)	304 (34.9)	
Additional injuries				
–Yes	44 (57.9)	515 (64.9)	559 (64.3)	χ^2=1.80, p=0.41
–No	28 (36.8)	234 (29.5)	262 (30.1)	
–Unknown	4 (5.3)	45 (5.7)	49 (5.6)	
Intent				
–Intentional	14 (18.4)	102 (12.9)	116 (13.3)	χ^2=2.62, p=0.27
–Unintentional	57 (75.0)	655 (82.5)	712 (81.8)	
–Unknown	5 (6.6)	37 (4.7)	42 (4.6)	
Mechanism of injury				
–Assault	13 (17.1)	97 (12.2)	110 (12.6)	χ^2=3.28, p=0.51
–Exposure to mechanical force	18 (23.7)	178 (22.4)	196 (22.5)	
–Fall	28 (36.8)	313 (39.4)	341 (39.2)	
–Motor vehicle crash	12 (15.8)	171 (21.5)	183 (21.0))	
–Other	2 (2.6)	6 (0.8)	8 (0.9)	
–Unknown	3 (3.9)	29 (3.6)	31 (3.6)	
Context				
–Sports and recreational	35 (46.1)	350 (44.1)	385 (44.3)	χ^2=2.22, p=0.70
–Occupational	3 (3.9)	46 (5.8)	49 (5.6)	
–Activities of daily living	23 (30.3)	267 (33.6)	290 (33.3)	
–Conflict situation	13 (17.1)	99 (12.5)	34 (3.9)	
–Other/Unknown	2 (2.6)	32 (4.0)	112 (12.9)	
High Alcohol Use				
–Yes	6 (7.9)	102 (12.8)	108 (12.4)	χ^2=2.34, p=0.31
–No	42 (55.3)	451(56.8)	493 (56.7)	
–Unknown	28 (36.8)	241 (30.4)	269 (30.9)	
Substance Use				
–Yes	1 (1.3)	10 (1.3)	11 (1.3)	χ^2=0.73, p=0.70
–No	45 (59.2)	509 (64.1)	554 (63.7)	
–Unknown	30 (39.5)	275 (34.6)	305 (35.1)	

To account for differences in population characteristics, the incidence of TBI for Pacific people was compared to NZ census data on the Pacific population of the study region. As shown in Table 2, peaks in TBI incidence were observed for 0–4 and 15–24 year olds.

For young infants, injuries were sustained most commonly by falls (83.3%) and motor vehicle accidents (16.7%). For the 15–24 year olds the main mechanisms of injury were assaults (45.5%) and exposure to mechanical forces (27.3%), with a third of injuries sustained whilst engaged in sport or recreational activities. There was a higher incidence of TBI for Pacific people in those aged over 35 years in comparison to rates of NZ Europeans (Tables 2 and 3).

Table 2. TBI incidence rates by mid-decade age bands

Variables	Population (N)	TBI cases (N)	Incidence per 100,000 person-years (95% CI)
Pacific people			
0–4 years	915	12	1311 (678–2291)
5–14 years	1650	15	909 (509–1499)
15–24 years	1215	22	1811 (1135–2741)
25–34 years	918	11	1198 (598–2144)
35–44 years	678	7	1032 (415–2127)
>45 years	741	9	1215 (555–2306)
Total	**6117**	**76**	**1242 (979–1555)**
NZ Europeans			
0–4 years	5478	92	1679 (1354–2060)
5–14 years	11,712	123	1050 (873–1253)
15–24 years	14,445	222	1537(1341–1753)
25–34 years	11,844	95	802 (649–981)
35–44 years	13,581	74	545 (428–684)
>45 years	37,266	188	505 (435–582)
Total	**94,326**	**794**	**842 (784–902)**

Table 3 outlines the healthcare service use at the time of injury and discharge location. There were no statistically significant differences in this data between the two groups. No TBI cases in Pacific people were ascertained from community support organisations such as the brain injury associations. The majority of TBI cases for all ethnicities were discharged home following medical consultation.

http://www.nzma.org.nz/journal/read-the-journal/all-issues/2010-2019/2015/vol-128-no-1412/6497

Table 3. Healthcare service use following TBI

Variables	Pacific people (N=76)	NZ European (N=794)	Total (N=870)	Test of difference
Medical consultation within 24hrs				
–Yes	69 (90.8)	645 (81.2)	714 (82.1)	χ^2=4.35, p=0.11
–No	6 (7.9)	133 (16.8)	139 (16.0)	
–Unknown	1 (1.3)	16 (2)	17 (2.0)	
Outcome of medical consultation (at any time following injury)				
–Discharged home	50 (65.8)	547 (68.9)	597 (68.6)	χ^2=7.38, p=0.12
–Hospitalised	18 (23.7)	122 (15.4)	140 (13.1)	
–Referred	1 (1.3)	32 (4.0)	33 (3.8)	
–Patient left against advice	3 (3.9)	15 (1.9)	18 (2.1)	
–Other/unknown	4 (5.2)	78 (9.8)	82 (9.4)	
CT scan received				
Unknown	60 (78.9)	672 (84.6)	732 (84.1)	χ^2=1.68, p=0.19
Yes	16 (21.1)	122 (15.4)	138 (15.9)	

* denotes P<0.05

Discussion

Pacific people have a significantly greater incidence of TBI than NZ Europeans. The incidence rates of TBI for Pacific people found in this study are higher than previous incidence rates in New Zealand.

The increased TBI incidence may reflect the intensive recruitment approaches in this study methodology which utilised hot pursuit methods[17] and inclusion of people with mild TBI who did not seek medical treatment (medical treatment is a requirement for inclusion in most previous studies).[7,22]

The increased incidence of TBI for Pacific people highlights not only the need for additional population-based studies to provide a true indication of the scale of the problem of TBI, but also confirms the findings of previous studies revealing that ethnic minority groups are at higher risk of TBI.[3,4,7,9,22–25]

Indeed, the finding that a quarter of the Pacific people group had experienced a previous TBI highlights a need for an increased focus on TBI prevention. The findings suggest that a targeted, rather than universal approach to prevention and management addressing both the mechanism and context of injuries may be needed.

A high proportion of injuries for both Pacific people and NZ Europeans were classified as being in the mild range which is comparable with incidence data for NZ Europeans. Although classified as mild in severity, it is now clear that many people experience persistent symptoms for many years following a mild TBI.[2] Therefore it is important that mild injuries, including those in people who do not seek medical treatment, are included within incidence estimates, a key strength of this study.

Similar to the findings for NZ Europeans, peaks in TBI incidence in the Pacific population were observed in very young children (0–4 years) and young adults (15–24 years). Falls are common in young children as they develop their gross motor skills and balance. For young adults, the most common mechanisms of injury were different, with a third of injuries were sustained through engagement in sports and recreation activities and 46% sustained through intentional assault.

In comparison to incidence rates for NZ Europeans across the age groups, incidence rates were higher for Pacific people in adults aged over 35 years, however this finding may well be reflective of the low number of TBI cases in this age range.

Whilst the findings in Table 1 suggest that injuries may be sustained at a younger age in for Pacific people, this may reflect the younger age of the Pacific people population within the study region. Reference to peaks in incidence identified against population census data are therefore more likely to reflect the nature of injuries within the Pacific population.

Pacific males were found to be at higher risk of sustaining a TBI than females, a trend also observed in NZ Europeans and consistent with the international literature on the epidemiology of TBI[16] and risk factors identified in ethnic minority groups.[16]

In a Fijian study based on data from a trauma registry (including hospital admissions and deaths),[26] similar trends in the age and gender profile of TBI for Pacific people were identified. Males were three times more likely to sustain a head injury than females and the majority of head injuries occurred between the ages of 0–24 years.

In terms of the context where TBIs were sustained, sport and recreational activities were the main activities engaged in at the time of injury among Pacific people and NZ European people. There is little research available in ethnic minorities to compare the context of injury. However, recent studies of the general population[27,28] have revealed that 38.6% and 6.4% respectively of head injuries admitted to emergency department or hospital were sports and recreation related.

Whilst rates of injury from sport and recreational activities is toward the higher end of the range found in previous research into TBI, the levels of sports-related injuries in this current analysis albeit high, were lower than in Canada as reported by Harris et al.[27]

It is unclear if these disparities reflect differences in the culture of the different populations studied. There are many well-known benefits to engaging in physical activity including improved physical and mental wellbeing.[29] These findings suggest the need for engagement with Pacific communities to develop strategies to promote safety and the prevention of head injuries within the context of sport and activities of daily living to reduce the risk of TBI.

There are inherent challenges in classifying ethnicity into groups as people frequently associate themselves with several ethnicities. Prioritising ethnicity according to the study aims is a useful strategy to facilitate comparisons, however this approach is limited as it may not necessarily reflect how people would classify themselves. In previous studies, it was often unclear as to how ethnicity was defined, for example, whether ethnicity has been self-reported or how ethnicity was prioritised.

Providing details of how ethnicity is defined will be important in future research to facilitate comparisons between studies. It is acknowledged that the low case numbers for Pacific people have resulted in high confidence intervals particularly for older adults and the findings should therefore be interpreted with caution. Additionally the low TBI case numbers for Pacific people precluded the exploration of potential risk factors through regression modelling such as the influence of socioeconomic status on TBI incidence.

It should also be acknowledged that the Pacific population of the Hamilton and Waikato regions of NZ may not be representative of the national Pacific population. However the focus on TBI in Pacific people using a population based sample has assisted in identifying who and how people are at risk of TBI to inform prevention efforts.

This study revealed that there appears to be good awareness of the need to seek medical attention following injury in Pacific people, with higher rates of seeking medical advice in comparison to NZ Europeans. However, despite the extensive case ascertainment procedures used to identify all TBI cases from a range of acute care and community based sources, it is acknowledged that there may be some cases of TBI who did not seek medical attention or who sought advice from other sources that were not captured within this study.

Whilst the difference did not reach statistical significance, it appeared there was a trend towards increased use of accident and medical clinics in comparison to NZ Europeans which suggests that Pacific people prefer to seek medical advice through such facilities.[30]

There is consensus that people should always seek medical attention following a brain injury (however mild) due to the risk delayed symptom onset and possible secondary injury. However, there is no defined pathway as to which services should be accessed in mild TBI where the risk of complications is low (e.g. people experiencing no or few early symptoms or symptoms that resolve within hours).

There is an argument that some mild brain injuries can be managed well within the community, reducing the burden on hospital services, increasing patient choice and facilitating access to culturally specific services if preferred. However, there is currently a lack of accuracy in predicting those who will go on to experience persistent difficulties over time. The observed ethnic differences in regard to 'where' people seek medical attention following TBI could inform the development of the most 'accessible' services to specific groups and therefore effective pathways for the management of mild TBI that responds to cultural needs.

Future research needs to investigate if there are any ethnic disparities in long-term health outcome for Pacific people to ensure current services are culturally appropriate and meeting the needs of Pacific people.

Conclusion

This is the first population-based study to describe TBI in the Pacific population of New Zealand. Pacific people were found to have significantly increased incidence of TBI in comparison to NZ Europeans. TBIs for Pacific people were most commonly sustained through falls or exposure to mechanical forces, with a high proportion of injuries sustained whilst engaging in in sport and recreational activities. This study highlights the need for TBI prevention programmes that engage with, and focus on the Pacific community to reduce the risk of TBI.

Competing interests: Nil.

***BIONIC Research Group members:** Valery Feigin, Alice Theadom, Suzanne Barker-Collo, Kelly Jones, Kathryn McPherson, Amy Jones, Braden Te Ao, Paul Brown, Peggy Fairbairn-Dunlop (AUT); Rob Kydd, P Alan Barber, Varsha Parag, Shanthi Ameratunga (University of Auckland); Nicola Starkey (University of Waikato); Tony Dowell (University of Otago); Michael Kahan, Grant Christey (Waikato DHB); Natalie Hardaker (ACC).

Author information: Wesley Lagolago, Research Assistant, National Institute for Stroke and Applied Neurosciences, Auckland University of Technology (AUT), Auckland; Alice Theadom, Senior Research Fellow, National Institute for Stroke and Applied Neurosciences, AUT, Auckland; Peggy Fairbairn-Dunlop, Professor of Pacific Studies, Institute of Public Policy, AUT, Auckland; Shanthi Ameratunga, Professor of Epidemiology, Section of Epidemiology & Biostatistics, School of Population Health, University of Auckland; Tony Dowell, Professor of Primary Health Care, Primary Health Care and General Practice, University of Otago, Wellington; Kathryn McPherson, Professor of Rehabilitation, Person Centred Research Centre, AUT, Auckland; Braden Te Ao, PhD Student and Māori Health Researcher, National institute for Stroke and Applied Neurosciences, AUT, Auckland; Nicola Starkey, Associate Professor of Psychology, School of Psychology, University of Waikato, Hamilton; Valery L Feigin, Consultant Neurologist and Professor of Neurology and Epidemiology, National Institute for Stroke and Applied Neurosciences, AUT, Auckland

Acknowledgements: This project was funded by Health Research Council of New Zealand project grants (Reference 09/063A and 11/192) and a Health Research Council of New Zealand Pasifika Health Summer Studentship Award. We thank the research team for their dedication and performance, the staff at the Coroner's office in Hamilton; the staff of the New Zealand Accident Compensation Corporation and Health

Information Service; Waikato District Health Board; Waikato University Staff; the many doctors, nurses and rehabilitation professionals and service providers such as ABI Management and administrative staff within and outside Hamilton; and the BIONIC participants and their families and friends. We also thank Helen McDonald for her administrative support for the study.

Correspondence: Dr Alice Theadom, National Institute for Stroke and Applied Neuroscience, School of Rehabilitation and Occupation Studies, Faculty of Health and Environmental Studies, Auckland University of Technology, AA254C, AUT North Shore Campus, 90 Akoranga Drive, Auckland, 1010, New Zealand. alice.theadom@aut.ac.nz

References

1. Langlois JA, Rutland-Brown W, Wald MM. The epidemiology and impact of traumatic brain injury: a brief overview. Journal of Head Trauma Rehabilitation. 2006 Sep-Oct;21(5):375–378.
2. McMahon P, Hricik A, Yue JK, et al. Symptomatology and Functional Outcome in Mild Traumatic Brain Injury: Results from the Prospective TRACK-TBI Study. Journal of Neurotrauma. 2014;31(1):26–33.
3. Bowman SM, Martin DP, Sharar SR, et al. Racial disparities in outcomes of persons with moderate to severe traumatic brain injury. Medical Care. 2007;45(7):686–690.
4. Burnett DM, Kolakowsky-Hayner SA, Slater D, et al. Ethnographic analysis of traumatic brain injury patients in the national Model Systems database. Archives of Physical Medicine and Rehabilitation. 2003;84(2):263–267.
5. Chang PF, Ostir GV, Kuo YF, et al. Ethnic differences in discharge destination among older patients with traumatic brain injury. Arch Phys Med Rehabil. 2008;89(2):231–236.
6. Bazarian J, Pope C, McClung J, et al. Ethnic and racial disparities in emergency department case. Academic Emergency Medicine. 2003;10:1209–1217.
7. Barker-Collo SL, Wilde NJ, Feigin VL. Trends in Head Injury Incidence in New Zealand: A Hospital-Based Study from 1997/1998 to 2003/2004. Neuroepidemiology. 2008 November 8;32(1):32–39.
8. Langlois JA, Kegler SR, Butler JA, et al. Traumatic brain injury-related hospital discharge. Morbidity and Mortality Weekly Report Surveillance Summaries. 2003;52(4):1–20.
9. Rutland-Brown W, Wallace LJD, Faul MD, et al. Traumatic brain injury hospitalizations among American Indians/Alaska Natives. Journal of Head Trauma Rehabilitation. 2005 May-Jun;20(3):205–214.
10. Kalyan S, Nadasan T, Puckree T. The Epidemiology of Traumatic Brain Injuries (TBI) – A Literature Review. South African Journal of Physiotherapy. 2007;63(3):32–36.
11. Humphreys I, Wood RL, Phillips CJ, et al. The cost of traumatic brain injury: a literature review. Clinicoeconomics and Outcome Research. 2013;13(5):281–287.
12. Cassidy JD, Carroll LJ, Peloso PM, et al. Incidence, risk factors and prevention of mild traumatic brain injury: results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. Journal of Rehabilitation Medicine. 2004 Feb;(43 Suppl):28–60.
13. Powell JM, Ferraro JV, Dikmen SS, et al. Accuracy of mild traumatic brain injury diagnosis. Archives of Physical Medicine & Rehabilitation. 2008 Aug;89(8):1550–1555.
14. Wright S, Hornblow A. Emerging needs, evolving services: the health of Pacific peoples in New Zealand. Kōtuitui: New Zealand Journal of Social Sciences Online. 2008;3:21–33.
15. New Zelaand Guidelines Group. The diagnosis, acute management and rehabilitation of people after traumatic brain injury. Wellington: New Zealand Guidelines Group; 2006.

16. Feigin VF, Theadom A, Barker-Collo SL, et al. Incidence of traumatic brain injury in New Zealand: a population-based study. The Lancet Neurology. 2013;12(1):53–64.
17. Theadom A, Barker-Collo S, Feigin V, et al. The spectrum captured: a methodological approach to studying incidence and outcomes of traumatic brain injury on a population level. Neuroepidemiology. 2012;38(1):18–29.
18. Carroll LJ, Cassidy JD, Holm L, et al. Methodological issues and research recommendations for mild traumatic brain injury: the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. Journal of Rehabilitation Medicine. 2004;43 Suppl:113–125.
19. Statistics New Zealand. 2006 Census Data. 2009 http://www.stats.govt.nz/methods_and_services/information-releases/2006-census.aspx
20. Servadei F, Teasdale G, Merry G. Defining acute mild head injury in adults: a proposal based on prognostic factors, diagnosis and management. Journal of Neurotrauma. 2001;18(7):657–664.
21. IBM SPSS Statistics for Windows, Version 20.0 [computer program]: Armonk, NY: IBM Corp; 2011.
22. Bazarian JJ, Pope C, McClung J, et al. Ethnic and racial disparities in emergency department care for mild traumatic brain injury. Academic Emergency Medicine. 2003;10(11):1209–1217.
23. Egede LE, Dismuke C, Echols C. Racial/Ethnic disparities in mortality risk among US veterans with traumatic brain injury. American Journal of Public Health,. 2012;102(Suppl 2):S266–271.
24. Jamieson LM, Harrison JE, Berry JG. Hospitalisation for head injury due to assault among Indigenous and non-Indigenous Australians. Medical Journal of Australia. 2008;188(10):576–579.
25. Langlois JA, Rutland-Brown W, Thomas KE. The incidence of traumatic brain injury among children in the United States: differences by race. Journal of Head Trauma Rehabilitation. May-Jun 2005;20(3):229–238.
26. Kool B, Raj N, Wainiqolo I, et al. Hospitalised and fatal head injuries in Viti Levu, Fiji: Findings from an island-wide Trauma Registry (TRIP 4). Neuroepidemiology. 2012;38(3):179–185.
27. Harris AW, Jones CA, Rowe BH, et al. A population-based study of sport and recreation-related head injuries treated in a Canadian health region. Journal of Science and Medicine in Sport. Jul 2012;15(4):298–304.
28. Parchani A, El-Menyar A, Al-Thani H, et al. Recreational-related head injuries in Qatar. Brain Injury. 2013;27(12):1450–1453.
29. Penedo FJ, Dahn JR. Exercise and well-being: a review of mental and physical health benefits associated with physical activity. Current Opinion Psychiatry. 2005;18(2):189–193.
30. Sopoaga F, Parkin L, Gray A. A Pacific population's access to and use of health services in Dunedin. New Zealand Medical Journal. 2012;125(1364):27–36.