Australasian Emergency Care 28 (2025) 213–220

Contents lists available at ScienceDirect

Australasian Emergency Care

journal homepage: www.elsevier.com/locate/auec

Mild and moderate traumatic brain injury: Screening, documentation, and referral to concussion services

Mahdi Zangi [a], John W. Pickering [b,c], Alice Theadom [d], Martin Than [c], Deborah L. Snell [a,e,*]

[a] Department of Orthopedic Surgery & Musculoskeletal Medicine, University of Otago, Christchurch, New Zealand
[b] Department of Medicine, University of Otago, Christchurch, New Zealand
[c] Department of Emergency Medicine, Christchurch Hospital, Christchurch, New Zealand
[d] TBI Network, Department of Psychology, Faculty of Health and Environmental Sciences, Auckland University of Technology, Auckland, New Zealand
[e] Concussion Service, Burwood Hospital, Christchurch, New Zealand

ARTICLE INFO

Keywords:
Traumatic Brain Injury
Incidence
Documentation
Referral

ABSTRACT

Background and aim: Screening of traumatic brain injuries (TBI) using different clinical assessment tools would facilitate diagnosis and effective inpatient follow-up. We aimed to describe rates of diagnosis, classification, documentation, and referral practices for TBI inpatients.

Material and methods: In a retrospective cohort study, we reviewed electronic clinical records of adult patients admitted to a hospital ward with head trauma from an emergency department (ED) in 2021. Data included demographics, injury, TBI diagnoses, and referral to concussion services. Factors predicting ED physician documentation and referral to concussion services were identified.

Results: Of approximately 34,000 adults admitted from the ED, 1059 presented with head trauma, and 609 (57.5 %) were diagnosed with TBI. There were 553 mild/moderate TBI cases with an incidence rate of 103.4 per 100,000 adult population in Canterbury. 14 % (n = 77) were referred to a concussion service.

Predictors of ED-documented TBI included non-isolated head injury (OR:0.60), head CT request (OR:9.12), injured in street/public areas (OR:2.03). Older age and non-isolated head injury decreased odds of concussion service referral (0.96 and 0.46, respectively), while female and ED-documented TBI increased odds of referral (5.8 and 28, respectively).

Conclusion: Better documentation of mild/moderate TBI might facilitate health care access, with efficient clinical decision making.

Background

Traumatic brain injury (TBI) affects 69 million people worldwide annually, of whom 55.9 million sustain mild/moderate TBI [1]. The 2016 global burden of disease systematic analysis found the years of life lived with disability (YLDs) for TBI were 8.1 million [2]. In NZ, approximately 36,000 people sustain TBI annually, of whom more than 35,000 sustain mild/moderate TBI [3]. The costs of TBI may include hospital and outpatient costs, community support, and productivity loss [4]. In addition to physical complications, many people experience cognitive, emotional, and behavioural problems, which may adversely impact education, employment and independent living [5].

Clinical studies have widely used the International Classification of Disease (ICD) codes to identify TBI [6–8] and the Glasgow Coma Scale (GCS) score to classify the severity of TBI [9–15]. Diagnosis of mild TBI is largely based on World Health Organisation (WHO) criteria including GCS and/or loss of consciousness (LOC), confusion/disorientation, post traumatic amnesia (PTA), and computed tomography (CT) scan findings [16–20]. Accurate TBI diagnosis and documentation in the emergency department (ED) facilitates appropriate handover, yet, in one previous study from 2009 to 2013 in a United States ED, it was observed that almost half of the patients did not have their diagnosis of TBI documented. The findings indicated that documentation of TBI was incomplete and needed improvement [21]. While some hospitals have a policy to provide verbal or written discharge instructions, as well as offer a follow-up appointment [15,20], the extent to which this occurs is not yet well understood. Factors such as age, sex, ethnicity, GCS score, head CT scan findings, and hospital length of stay may affect the likelihood of

* Corresponding author at: Department of Orthopedic Surgery & Musculoskeletal Medicine, University of Otago, Christchurch, New Zealand.
E-mail address: debbie.snell@otago.ac.nz (D.L. Snell).

https://doi.org/10.1016/j.auec.2025.03.007
Received 22 December 2024; Received in revised form 23 March 2025; Accepted 25 March 2025
Available online 9 April 2025

patients receiving follow-up care [9, 20, 22], though the relevance of these factors in NZ for referrals from the ED remains unclear.

It is important to focus on the admitted cohort of patients with mild and moderate TBI, as they often represent a "hidden population" in the healthcare system. They are in danger of receiving incomplete care because of the fragmentation of care when transitioning between different services in the hospital. Most times, documentation of the TBI diagnosis is lost in discharge or overridden by other active clinical issues [21], which significantly contributes to follow-up care gaps and missed opportunities for proper referral to concussion services. Moreover, this admitted cohort may get less attention than those with severe TBI, who are more readily identified, or those patients being discharged directly from the ED, who are often flagged for follow-up. Most patients with mild to moderate TBI have their diagnosis overlooked due to a lack of proper screening, documentation, and referral pathways; hence, the likelihood of long-term consequences like impairments in cognition or functional attributes increases.

Insights on factors influencing documentation and referral processes at ED may give opportunities to design and implement efficient interventions to improve health pathways and patient outcomes. This study reviewed patients with head trauma who presented to the largest ED (Christchurch hospital) in New Zealand in 2021 to describe rates of diagnosis, classification, documentation, and referral practices.

Material and methods

Design

In a retrospective cohort study, we charted and reviewed all electronically available clinical records of adult patients admitted with TBI from the Christchurch Hospital ED in one calendar year. We obtained ethics approval from the University of Otago Human Ethics Committee

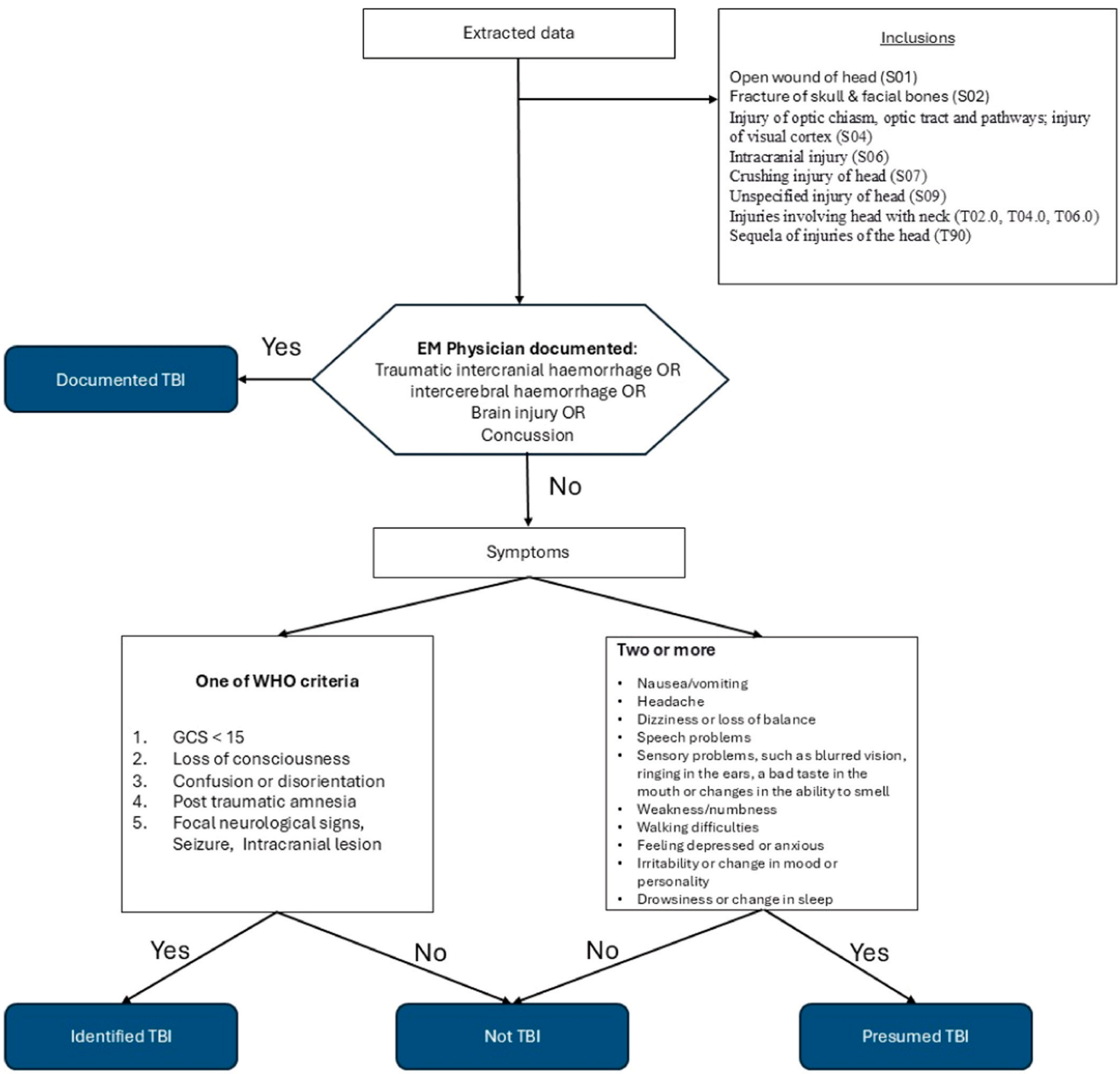

Fig. 1. TBI diagnosis Flowchart.

(HD22/058).

Setting and participants

Canterbury, a region located in the central-eastern South Island of NZ, had an estimated 535,000 adults aged 16 and over in 2021[23]. We included all adult patients (aged 16 or over) admitted inwards with head trauma (ICD10 S01-S09; Appendix 1) presenting to the Christchurch Hospital ED in Canterbury from January to December 2021 [24]. Exclusion criteria were patients with a GCS < 9.

Data collection

Data extracted from the medical record included demographics (age, gender, ethnicity, pre-injury mental health history), injury details (arrival complaint, triage (Australasian triage scale) [25], GCS, injury cause, place of trauma, admission and discharge time, injury diagnosis, and brain imaging), TBI diagnosis (PTA, TBI symptom/signs, documented TBI diagnosis), disposition and follow-up (length of stay, type of discharge, referrals). Data were entered into REDCap [26] before extraction into STATA for analysis.

TBI definition and determination

We classified patients as "ED-documented TBI", "identified TBI", or "presumed TBI" (see Fig. 1). The severity of TBI was defined by the lowest GCS or PTA from the time of injury to the disposition of patients. Mild TBI was defined as GCS 13–15 and PTA < 1 day from injury and Moderate TBI as GCS 9–12 or PTA 1–6 days from injury. Severe TBI was defined as GCS ≤ 8 or PTA ≥ 7 days from injury. All records were reviewed by one researcher for consistency (MZ), with random quality assurance by another researcher (DS). Different causes of injuries and locations of injuries were categorised according to ICD10 [24].

Data analysis

STATA software (version 18) was used for all statistical analyses. We calculated age and sex-adjusted incidence rates for mild/moderate TBI. We combined identified and presumed TBI cases under "Researcher-defined TBI". Logistic regression models were used to identify factors affecting the documentation of TBI and referral of patients with mild/moderate TBI. We conducted univariate analyses and then multivariable analysis adjusting for demographic, injury, hospital, and TBI-related variables contributing to the documentation of TBIs and referrals to concussion services using binary logistic regression. Estimated metrics are presented with 95 % confidence intervals (CI95).

Results

Approximately 33,800 adults attended the ED and were admitted into the hospital (female; 51.86 %) over 12 months. Among them, 1071 (3.2 %) were identified as having head trauma. Following chart review, 12 cases were excluded due to unclear evidence of head trauma, leaving 1059 head trauma patients for analysis of whom 57.3 % (n = 607) were male, Appendix 3. The median age was 71 years, ranging from 17 to 98. Most patients identified as NZ European (80.4 %), followed by Māori (9.9 %).

The majority of injuries (65.4 %) were caused by falls, followed by transport accidents (18.3 %) and assault (8.1 %). Intoxication (alcohol/drug) at the time of trauma was recorded in 12.6 % of patients, and 13.8 % had a history of mental health problems. Head CT scans were requested for 83.8 % of patients, of which 27.5 % showed positive results such as intracranial haemorrhage (see appendix 2). The overall median length of stay in the ED was 5.7 hours and the median hospital stay was 3.4 days. Most patients were transferred to general medicine (40.1 %), followed by orthopaedics (18.3 %), neurosurgery (13.3 %), and general surgery (10.0 %) (see appendix 3).

Four individuals with mild/moderate TBI died from unrelated causes during admission. Of the mild/moderate TBI patients, 33.1 % were discharged home with no follow-up, while the rest received at least one onward referral to GP (28.2 %), a medical specialist (24.6 %), transfer to other facilities (18.4 %), and/or directly to a concussion service (only 14 % (n = 77)).

Incidence rate

Of all ED admissions, 399 (37.7 %) were ED-documented TBIs, and 210 (19.8 %) cases that met the TBI criteria were Researcher-defined TBI. Therefore, the total number of TBI cases (mild, moderate and severe) was 609, indicating 1.8 % of patients admitted from the ED and a rate of 113.8 (CI95: 105.2–123.3) per 100,000 population in Canterbury.

After excluding severe TBI, 528 (86.7 %) cases were classified as mild TBI, and 25 (4.11 %) as moderate, which represents an incidence rate of 103.4 (CI95: 95.1–112.4) per 100,000 adults in Canterbury, and 121.4/100,000 (CI95:108.9–135.4) for males and 85.6/100,000 (CI95: 75.2–97.4) for females. The incidence rates of mild/moderate TBI were 99.1 (CI95: 90.3–108.9), 125.5 (CI95: 98.0–160.6), 32.0 (CI95: 20.4–50.1), and 41.4 (CI95: 19.8–86.9) per 100,000 adults in Canterbury for individuals of European, Māori, Asian, and Pacific ethnicities, respectively.

TBI diagnosis and documentation

Table 1 presents the characteristics of admitted patients with TBI diagnoses (n = 609) and mild/moderate TBI documentation (n = 553). Males accounted for 56.2 % of the mild/moderate ED-documented TBIs and 62.2 % of researcher-defined TBIs. The median age was 66 years in ED-documented TBIs and 71 years in researcher-defined TBIs. Most patients were NZ European in both groups (76.1 % ED-documented and 84.1 % researcher-defined). Falls were the leading cause of mild/moderate TBI in both groups (58.2 % for ED-documented and 66.2 % for researcher-defined), followed by transport accidents (29 % for ED-documented; 23.9 % for researcher-defined). Mild/moderate ED-documented TBIs had higher rates of head CT scan requests, longer hospital stays, experienced more isolated head trauma and were more frequently injured in public places.

Patients injured in street and public areas (adjusted OR: 2.0; CI95 1.0–4.1) and those who underwent a head CT scan (adjusted OR: 9.1; CI95 3.5–23.6) were linked with increased odds of be ED-documented TBI, while those with non-isolated head injury (adjusted OR: 0.6; CI95 0.4–0.9) were linked with decreased odds (see appendix 5).

TBI referral to concussion services

Table 2 presents the 77 admitted patients with TBI diagnoses referred to concussion services. Males comprised 51.9 % and 59.1 % of the referred and not-referred groups, respectively. Moreover, the referred group was younger (median age 37) than the not-referred group (median age 71). Most patients were NZ European, accounting for 63.6 % in the referred group and 81.5 % in the not-referred group. The following factors were associated with referral to a concussion service: older age and non-isolated head injury were linked with decreased odds of referral (adjusted OR=0.96; CI95 0.94–0.97 and adjusted OR=0.46; 95 %CI 0.3–0.8, respectively) while being female and ED-documentation TBI resulted in a 5.78 (CI95 1.5–5.1) and 28-fold (CI95 6.7–118.0) increase in adjusted odds of referral, respectively (see appendix 6).

Discussion

TBI severity was classified according to the lowest GCS or PTA.

Table 1
Demographic, injury, and hospital data for patients documented as mild and moderate TBI by ED physicians versus those defined as mild and moderate TBI by researcher (n = 553).

		All patients (n = 1059)	Mild or Moderate TBI (n = 553)	Researcher-defined TBI (n = 201)	ED-documented TBI (n = 352)	Difference between ED-documented and Research defined (CI95)	P value
Age in years, Median (IQR)		71 (40–83)	69 (40–83)	71 (43–82)	66 (36.5–83)	−5 (−12.3–2.3)	0.26
Sex n (%)	Male	607 (57.3)	323 (58.4)	125 (62.2)	198 (56.2)	−5.9 (−14.4–2.5)	0.17
Ethnicity n (%)							
	European	852 (80.5)	437 (79.0)	169 (84.1)	268 (76.1)		0.07
	Māori	105 (9.9)	63 (11.4)	19 (9. 5)	44 (12.5)		
	Asian	38 (3.6)	19 (3.4)	5 (2.5)	14 (4.0)		
	Pacific People	21 (2.0)	7 (1.3)	3 (1.5)	4 (1.1)		
	Middle Eastern/Latin American/African	6 (0.6)	3 (0.54)	2 (1.0)	1 (0.3)		
	Other Ethnicity	37 (3.5)	24 (4.3)	3 (1.5)	21 (6.0)		
Ethnicity, n (%)							
	Not Māori Not Pacific		483 (87.3)	179 (89.1)	304 (86.4)		0.55
	Māori		63 (11.4)	19 (9. 5)	44 (12.5)		
	Pacific		7 (1.3)	3 (1.5)	4 (1.1)		
Mental health history n (%)		146 (13.8)	86 (15.5)	35 (17.4)	51 (14.5)	−2.9 (−9.3–3.5)	0.36
Intoxication n (%)		134 (12.7)	73 (13.2)	28 (13.9)	45 (12. 8)	−1.1 (−7.1–4.8)	0.70
Arrival Method n (%)							
	Ambulance	765 (72.2)	400 (72.3)	148 (73.6)	252 (71.6)		0.21
	Walk-in	224 (21.2)	108 (19.5)	43 (21.4)	65 (18.5)		
	Helicopter	63 (6.0)	40 (7.2)	9 (4.5)	31 (8.8)		
	Police	7 (0.7)	5 (0.9)	1 (0.5)	4 (1.1)		
Arrival day n (%)							
	Weekday	670 (63.2)	350 (63.3)	123 (61.2)	227 (64.5)		0.44
	Weekend	389 (36.8)	203 (36.7)	78 (38.8)	125 (35.5)		
Triage n (%)							
	1	104 (9.8)	39 (7.1)	8 (4.0)	31 (8.8)		0.12
	2	260 (25.6)	156 (28.2)	54 (26.9)	102 (29.0)		
	3	602 (56.9)	326 (58.9)	125 (62.2)	201 (57.1)		
	4	91 (8.6)	32 (5.8)	14 (7.0)	18 (5.1)		
	5	2 (0.19)	0	0			
GCS n (%)							
	Severe	63 (6)	2 (0.3)	0	2 (0.6)		0.19
	Moderate	35 (3.3)	26 (4.7)	6 (3.0)	20 (5.7)		
	Mild	961 (90.8)	525 (94.9)	195 (97.0)	330 (93.8)		
Cause of Injury n (%)							
	Falls	693 (65.4)	338 (61.1)	133 (66.2)	205 (58.2)		0.49
	Transport accident	220 (20.7)	150 (27.1)	48 (23.9)	102 (29.0)		
	Assault	86 (8.1)	42 (7.6)	13 (6.5)	29 (8.2)		
	Exposure to inanimate/ animate mechanical forces	40 (3.8)	17 (3.1)	5 (2.5)	12 (3.4)		
	Other	20 (1.9)	6 (1.1)	2 (1.0)	4 (1.1)		
Place of Injury n (%)							
	Non-institutional (private) residence	411 (38.8)	210 (38.0)	95 (47.3)	115 (32. 7)		
	Street, highway, and other paved roadways	217 (20.5)	137 (24.8)	44 (21. 9)	93 (26.4)		0.02
	Institutional (nonprivate) residence	101 (9.5)	56 (10.1)	18 (9.0)	38 (10.8)		
	School, other institution and public, Sports and athletics area	98 (9.3)	34 (6.2)	9 (4.5)	25 (7.1)		
	Other places	232 (21.9)	116 (21.0)	35 (17.4)	81 (23.0)		
Not-Isolated Head Trauma n (%)		508 (47.9)	275 (49.7)	111 (55.2)	164 (46.6)	−8.6 (−17.3–0)	0.051
Head CT requested n (%)		887 (83.8)	521 (94.2)	175 (87.1)	346 (98.3)	11.2 (6.4–16.1)	< 0.01
POSTIVE CT (521) n (%)				0 (0)	207 (59.8)		< 0.01

(*continued on next page*)

Table 1 (*continued*)

	All patients (n = 1059)	Mild or Moderate TBI (n = 553)	Researcher-defined TBI (n = 201)	ED-documented TBI (n = 352)	Difference between ED-documented and Research defined (CI95)	P value
ED LOS (hours), Median (IQR)	5.7 (4.1–7.5)	6.1 (4.6–7.9)	6.2 (4.7–9.7)	5.9 (4.5–10.0)	−0.2 (−0.7–0.2)	0.76
Hospital LOS (days), Median (IQR)	3.7 (1.7–7.7)	3.2 (1.6–7.0)	2.7 (1.5–5.1)	3.8 (1.7–7.9)	1.1 (0.3–1.9)	< 0.01

Metrics are n (%) unless otherwise indicated, CI95: 95 % confidence interval, GCS=Glasgow Coma Scale, LOS: Length of Stay, TBI: Traumatic brain injury; ED: Emergency Department, Triage (Australasian triage scale)

Patients with mild/moderate TBI were identified as ED-documented or researcher-defined TBIs. Approximately 20 % were not documented at the ED level as TBI, with follow-up consequences being poor healthcare.

The estimated incidence rate for admitted mild/moderate TBI, 103.4 per 100,000 adult population, was similar to previous studies, such as a hospital-based survey in New South Wales, Australia (99.1 per 100,000) [27], and a hospital-based study in Oslo (83.3 per 100,000) [28]. Both the current study and the Oslo study had higher incidence for males than females. Different incidence rates of TBI or mild TBI between studies and reports reflected varied study designs, data sources, and TBI definitions. For example, a NZ-based study that included people who presented to primary care [29] estimated a higher the incidence rate at 790 per 100, 000 person-years.

The median age, 69, and percentage of males admitted, 58.4 % were comparable with the European CENTER-TBI study [12], in which the median age was 53 years, and males were predominant (64.9 %). Pruitt et al. [30] and Dengler et al. [31] showed the median age for hospitalized mild TBI were 60 and 44 years old, with 61 % and 67.7 % being males, respectively. The findings may therefore reflect differences in healthcare seeking behaviour following TBI in older adults. The leading cause of injuries was falls (61.1 %), followed by road transport accidents (27.1 %) and assault (7.6 %) in the current study. The European CENTER-TBI study [12] showed lower rates of TBI caused by falls (50.8 %) and higher rates by road traffic accidents (32.7 %). In contrast, in Pruitt 's study [30], the proportion of TBI caused by falls (69.9 %) was higher than in our study.

The regression model showed that patients for whom a head CT scan was requested (OR: 9.1) and injured patient in public or street areas (OR: 2.0) were more likely to receive a documented ED diagnosis of TBI. In contrast, those with non-isolated head injuries were 40 % less likely to have their TBI documented. These findings were comparable to Cota and colleagues' study [21], which indicated that patients with negative CT (OR: 19.4), road traffic accidents (OR: 2.1), or assaults (OR: 2.1) were less likely to be documented as TBI. Additionally, Powel's findings [32] demonstrated that males (OR: 2.1), admitted patients (OR: 2.5), and patients with confusion (OR: 3.5), amnesia (OR: 3), or LOC (OR: 2.7) were more likely to be documented as having mild TBI in the ED. The differences between our study and Cota's and Powel's [21,32] may stem from the study's retrospective nature and available data and the sole focus on hospitalized patients with mild/moderate TBI.

Females and ED documentation of TBI resulted in an increase in the odds of direct referral to a concussion service, while older age and non-isolated head injury were linked with decreased odds. Investigations by Crandall et.al [20] and Yue et.al [22] showed similar referral patterns, with 25 % and 60 % of mild TBI patients, respectively referred on. In addition, older patients and those with longer hospital stays were more likely to receive outpatient follow-up care.

The mild/moderate TBI incidence rates were highest among patients with Māori ethnicity (125.45 per 100,000), but Māori had 39 % lower odds of being referred to a concussion service compared to NZ European (CI95: 0.3–1.4). Crandall et.al [20] and Yue et.al [22] also identified that patients without insurance or a full-time job, African American or other non-white patients were less likely to have follow-up care after discharge. Moreover, Seabury et al. [9], demonstrated that females, non-Hispanic white patients and those with a 13 or 14 GCS score or positive head CT scan were more likely to be referred after discharge. This discrepancy in factors affecting the referral could be attributed to the varied study populations and referral systems between healthcare systems but highlight ethnic inequities in health care access.

Implications for further research

The higher incidence rate of TBI in Māori reveals a higher risk of TBI in NZ's indigenous population. Of concern is that the higher incidence rate was not reflected in rates of referral to concussion services, suggesting inequities in ED documentation and access to healthcare. Standardised assessment and referral may assist in reducing these health inequities. Although the nondocumented TBIs may have milder TBI and may be more likely to recover without sequelae, some of them might experience persistent physical/emotional symptoms [5]. Without a documented diagnosis, individuals can experience difficulties in getting injury insurance claim accepted, affecting their ability to access required services, receive educational information or recommendations about gradual return to activity and warning signs. ED physicians should ensure appropriate documentation of TBI according to diagnostic criteria and relevant symptoms/signs and consider the potential for missing TBI in multiple trauma patients due to severe concomitant injuries. Furthermore, providing educational information and regular reassessment of potential high-risk groups may lessen the risk of need for referral to concussion services through early education. The referral disparity may increase risk for persistent symptoms and consequences for older males with multiple trauma [9].

It is imperative to conduct further research in a prospective manner, including ED outpatients or inpatients, to examine the variation in identification, ED care, discharge and referral process as this is likely to vary regionally.

It is worth defining potential risk factors for inadequate documentation and missing follow-up/referral, focusing on subpopulations with a higher incidence rate of mild and moderate TBI to identify areas for improvement. A targeted approach with standardized documentation and clinician training could reduce inconsistencies in TBI identification and referrals. The next step might be an interventional study to implement and evaluate a multidisciplinary clinical pathway, including standardized clinical rules, assessment tools, and integrated referral forms, improving TBI diagnosis, follow-up and further referral. Other measures of evaluating referral compliance can also be implemented, e.g., GP or specialist follow-up verification, to assist with patient flow after ED discharge.

The use of standardized clinical rules, assessment tools (such as the Canadian CT rule [33], abbreviated Westmead PTA scale (A-WPTA) [34], a measure of symptom burden such as the Brain Injury Screening Tool (BIST) [35]) may reduce inconsistencies in documentation, management, and referral. A multidisciplinary clinical pathway involving ED nurses, Emergency physicians, occupational therapists, neurologists, and physiotherapists may improve documentation and patient flow following TBI. Developing a system for interdisciplinary collaboration and structured referral pathways tailored to regional healthcare availability might improve the accuracy of documentation and patient

Table 2
Demographic, injury, and hospital data for patients with identified mild and moderate who referred vs not referred.

Variable		Not Referred (n = 476)	Referred to concussion services (n = 77)	Difference (CI95)	P value
Age (years), Median (IQR)		71.5 (47−85)	37 (23−61)	−34.5 (−44.8 to −24.2)	< 0.01
Sex n (%)	Male	283 (59. 5)	40 (51.9)	−7.5 (−19.5–4.5)	
Ethnicity n (%)					
	European	388 (81.5)	49 (63.6)		< 0.01
	Māori	52 (10.9)	11 (14.3)		
	Asian	14 (2.9)	5 (6.5)		
	Pacific People	5 (1.1)	2 (2.6)		
	Middle Eastern/Latin American/African	2 (0.4)	1 (1.3)		
	Other Ethnicity	15 (3.2)	9 (11.7)		
Mental health history n (%)		74 (15.5)	12 (15.6)	0 (−8.7–8.8)	0.99
Intoxication n (%)		54 (11.3)	19 (24.7)	13.3 (3.2–23.4)	< 0.01
Arrival Method n (%)					
	Ambulance	349 (73.3)	51 (66.2)		0.07
	Walk-in	94 (19.7)	14 (18.2)		
	Helicopter	29 (6.1)	11 (14.3)		
	Police	4 (0.8)	1 (1.3)		
Arrival day n (%)					
	Weekday	305 (64.1)	45 (58.4)		0.34
	Weekend	171 (35.9)	32 (41.6)		
Triage n (%)					
	1	23 (4.8)	16 (20.8)		< 0.01
	2	127 (26.7)	29 (37.7)		
	3	295 (62.0)	31 (40.3)		
	4	31 (6.5)	1 (1.3)		
GCS n (%)					
	Severe	2 (0.42)	0		< 0.01
	Moderate	15 (3.15)	11 (14.29)		
	Mild	459 (96.43)	66 (85.71)		
Cause of Injury n (%)					
	Falls	311 (65.3)	27 (35.1)		< 0.01
	Transport accident	119 (25)	31 (40.3)		
	Assault	30 (6.3)	12 (15.6)		
	Exposure to inanimate/animate mechanical forces	12 (2.5)	5 (6.5)		
	Other	4 (0.8)	2 (2.6)		
Place of Injury n (%)					
	Non-institutional (private) residence	196 (41.2)	14 (18.2)		< 0.01
	Street, highway, and other paved roadways	110 (23.1)	27 (35.1)		
	Institutional (nonprivate) residence	52 (10.9)	4 (5.2)		
	School, other institution and public, Sports and athletics area	29 (6.1)	5 (6.5)		
	Other places	89 (18.7)	27 (35.1)		
Non-Isolated Head Trauma n (%)		245 (51.5)	30 (39.0)	−12.5 (−24.3–0.7)	0.04
Head CT requested n (%)		444 (93.3)	77 (100)	6.7 (4.5–9.0)	0.02
Head CT positive report for TBI (n = 521) n (%)		169 (38.1)	38 (49.4)	11.2 (−0.7–23.3)	0.06
Discharge type n (%)					
	Discharge to another health facility	94 (19.715)	8 (10.4)		< 0.05
	Discharge home	145 (30.5)	38 (49.4)		< 0.01
	Discharge with follow up by GP	140 (29.4)	16 (20. 8)		0.12
	Referral to medical Specialist	119 (25)	17 (22.1)		0.58
Documented TBI n (%)		277 (58.2)	75 (97.4)	39.2 (33.5–44.9)	< 0.01
Median ED LOS (hours), (IQR)		6.1 (4.7–7.9)	5.9 (4.5–7.9)	−0.17 (−1.0–0.7)	0.53
Median Hospital LOS (days), (IQR)		3.1 (1.6–6.9)	3.3 (1.9–8.2)	0.18 (1.1–1.4)	0.25

Metrics are n (%) unless otherwise indicated, CI95: 95 % confidence interval, GCS=Glasgow Coma Scale, LOS: Length of Stay, TBI: Traumatic brain injury outcomes following TBI.

Limitations

In our retrospective chart review, we utilized ICD-10 codes to include head trauma in hospitalized patients admitted from the ED. Some patients with head trauma might be not assigned the appropriate ICD-10 code and were misclassified under different codes. To address this, we included patients likely to be TBI based on WHO criteria and relevant literature, however some patients may still have been missed due to neglected details in the medical record. Inconsistencies in ED documentation and in the inpatients' discharge notes could influence the identification, disposition, follow-up, referral of TBIs, impacting internal validity. Patients advised to follow up with GPs or clinics might have been indirectly referred to concussion services, and we had no access to information about their potential referrals. Moreover, in an overcrowded ED setting, physicians prioritize critical patients, thus patients with mild/moderate TBI or severe concomitant injuries or medical conditions might have been overlooked in terms of TBI documentation. We employed the GCS score and PTA to classify TBI, however, intoxication (alcohol or drugs), comorbidities or acute medical conditions (dementia and delirium) could result in misclassification. We may expect to identify more TBI patients using the new guidelines from American Congress of Rehabilitation Medicine [36]. Unfortunately, we lacked access to injury insurance records to identify the proportion of referred patients who were referred to an appropriate concussion service after hospital discharge.

Our findings may have limited external validation and generalizability because the study was conducted at a single hospital in NZ and only included hospitalized patients with head trauma from the ED. The study provides no information on outpatients with head trauma or those who visited their GP or attended urgent care following their injury. Therefore, these findings do not generalize to all mild/moderate TBIs in the Canterbury region. Additionally, these findings are limited as many other potential influencing factors such as arrival method, intoxication, cause and place on injury were unable to be entered into the regression model due to the limited number of onward referrals reducing statistical power if too many variables were entered.

Conclusion

In this retrospective chart review, we examined adult patients with head trauma admitted from the main ED in the Canterbury region, NZ. The incidence rate was 103.4 per 100,000 yearly population for mild/moderate TBIs, with higher rates among Māori and males. Gender, age, ethnicity, associated injuries, location of injury, and head CT scan orders at the time of evaluation, affect documentation of TBI in ED, or direct to concussion services. We recommend further prospective study to uncover the full scope of inconsistencies in diagnosis, management, and referral from the ED to inpatients ward and concussion services.

Prior presentations

N/A

Funding sources

This research was supported by a University of Otago Doctoral Scholarship award.

Declaration of Competing Interest

This study was not commissioned and was independently reviewed. The authors have no conflicts of interest to declare.

Acknowledgments

N/A

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.auec.2025.03.007.

References

[1] Dewan MC, Rattani A, Gupta S, Baticulon RE, Hung Y-C, Punchak M, et al. Estimating the global incidence of traumatic brain injury. J Neurosurg 2018;130(4):1080–97.
[2] James SL, Theadom A, Ellenbogen RG, Bannick MS, Montjoy-Venning W, Lucchesi LR, et al. 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. Lancet Neurol 2019;18(1):56–87.
[3] Traumatic Brain Injury Strategy and Action Plan (2017–2021): Accident Compensation Corporation (ACC); 2017 [Available from: 〈https://www.acc.co.nz/assets/provider/1bf15d391c/tbi-strategy-action-plan.pdf〉].
[4] Te Ao B, Brown P, Tobias M, Ameratunga S, Barker-Collo S, Theadom A, et al. Cost of traumatic brain injury in New Zealand: evidence from a population-based study. Neurology 2014;83(18):1645–52.
[5] Finnanger TG, Olsen A, Skandsen T, Lydersen S, Vik A, Evensen KAI, et al. Life after adolescent and adult moderate and severe traumatic brain injury: self-reported executive, emotional, and behavioural function 2–5 years after Injury. Behav Neurol 2015;2015(1):329241.
[6] Vitale D, Bohan PK, How R, Arnold-Lloyd T, Aden JK, Sams V. Implementation of a traumatic brain injury guideline at a Department of Defense Level 1 trauma center. J Surg Res 2022;272:117–24.
[7] Tranter-Entwistle I, Evans M, Johns S, Fleischer D, Wakeman C. What a headache! Reviewing mild traumatic brain injury management in a new trauma service. NZ Med J (Online) 2021;134(1532):59. -6.
[8] Bazarian J, McClung J, Cheng Y, Flesher W, Schneider S. Emergency department management of mild traumatic brain injury in the USA. Emerg Med J 2005;22(7):473–7.
[9] Seabury SA, Gaudette É, Goldman DP, Markowitz AJ, Brooks J, McCrea MA, et al. Assessment of follow-up care after emergency department presentation for mild traumatic brain injury and concussion: results from the TRACK-TBI study. JAMA Netw Open 2018;1(1):e180210 (-e).
[10] Rogers S, Richards KC, Davidson M, Weinstein AA, Trickey AW. Description of the moderate brain injured patient and predictors of discharge to rehabilitation. Arch Phys Med Rehabil 2015;96(2):276–82.
[11] de Koning ME, Spikman JM, Coers A, Schönherr MC, van der Naalt J. Pathways of care the first year after moderate and severe traumatic brain injury—discharge destinations and outpatient follow-up. Brain Inj 2015;29(4):423–9.
[12] Steyerberg EW, Wiegers E, Sewalt C, Buki A, Citerio G, De Keyser V, et al. Case-mix, care pathways, and outcomes in patients with traumatic brain injury in CENTER-TBI: a European prospective, multicentre, longitudinal, cohort study. Lancet Neurol 2019;18(10):923–34.
[13] Ratcliff JJ, Adeoye O, Lindsell CJ, Hart KW, Pancioli A, McMullan JT, et al. ED disposition of the Glasgow Coma Scale 13 to 15 traumatic brain injury patient: analysis of the Transforming Research and Clinical Knowledge in TBI study. Am J Emerg Med 2014;32(8):844–50.
[14] Heskestad B, Baardsen R, Helseth E, Ingebrigtsen T. Guideline compliance in management of minimal, mild, and moderate head injury: high frequency of noncompliance among individual physicians despite strong guideline support from clinical leaders. J Trauma Acute Care Surg 2008;65(6):1309–13.
[15] Tavender EJ, Bosch M, Green S, O'Connor D, Pitt V, Phillips K, et al. Quality and consistency of guidelines for the management of mild traumatic brain injury in the emergency department. Acad Emerg Med 2011;18(8):880–9.
[16] Foks KA, Cnossen MC, Dippel DW, Maas AI, Menon D, van der Naalt J, et al. Management of mild traumatic brain injury at the emergency department and hospital admission in Europe: a survey of 71 neurotrauma centers participating in the CENTER-TBI study. J Neurotrauma 2017;34(17):2529–35.
[17] Pozzato I, Meares S, Kifley A, Craig A, Gillett M, Van Vu K, et al. Challenges in the acute identification of mild traumatic brain injuries: results from an emergency department surveillance study. BMJ Open 2020;10(2):e034494.
[18] Brown AM, Twomey DM, Shee AW. Evaluating mild traumatic brain injury management at a regional emergency department. Inj Prev 2018;24(5):390–4.
[19] Bergeron E, Clas D, Messier D, Pintal L, Mawn J, Godbout D, et al. Implementing a routine screening program in the acute care setting for mild traumatic brain injury. Eur J Trauma 2003;29:85–91.
[20] Crandall M, Rink RA, Shaheen AW, Butler B, Unger E, Zollman FS. Patterns and predictors of follow-up in patients with mild traumatic brain injury. Brain Inj 2014;28(11):1359–64.
[21] Cota MR, Moses AD, Jikaria NR, Bittner KC, Diaz-Arrastia RR, Latour LL, et al. Discordance between documented criteria and documented diagnosis of traumatic brain injury in the emergency department. J Neurotrauma 2019;36(8):1335–42.
[22] Yue JK, Winkler EA, Sharma S, Vassar MJ, Ratcliff JJ, Korley FK, et al. Temporal profile of care following mild traumatic brain injury: predictors of hospital

admission, follow-up referral and six-month outcome. Brain Inj 2017;31(13-14): 1820–9.
[23] Stats NZ–Tatauranga Aotearoa [Available from: ⟨https://www.stats.govt.nz/tools/nz-dot-stat⟩.
[24] World Health Organization. ICD-10: international statistical classification of diseases and related health problems: 10th rev. World Health Organization; 2004.
[25] Australasian college for Emergency Medicine. Policy on the Australasian triage scale. West Melbourne Australia: ACEM; 2013.
[26] Harris PA, Taylor R, Minor BL, Elliott V, Fernandez M, O'Neal L, et al. The REDCap consortium: building an international community of software platform partners. J Biomed Inform 2019;95:103208.
[27] Pozzato I, Tate RL, Rosenkoetter U, ID Cameron. Epidemiology of hospitalised traumatic brain injury in the state of New South Wales, Australia: a population-based study. Aust NZ J Public Health 2019;43(4):382–8.
[28] Andelic N, Sigurdardottir S, Brunborg C, Roe C. Incidence of hospital-treated traumatic brain injury in the Oslo population. Neuroepidemiology 2008;30(2): 120–8.
[29] Feigin VL, Theadom A, Barker-Collo S, Starkey NJ, McPherson K, Kahan M, et al. Incidence of traumatic brain injury in New Zealand: a population-based study. Lancet Neurol 2013;12(1):53–64.
[30] Pruitt P, Penn J, Peak D, Borczuk P. Identifying patients with mild traumatic intracranial hemorrhage at low risk of decompensation who are safe for ED observation. Am J Emerg Med 2017;35(2):255–9.
[31] Dengler BA, Plaza-Wüthrich S, Chick RC, Muir MT, Bartanusz V. Secondary overtriage in patients with complicated mild traumatic brain injury: an observational study and socioeconomic analysis of 1447 hospitalizations. Neurosurgery 2020;86(3):374–82.
[32] Powell JM, Ferraro JV, Dikmen SS, Temkin NR, Bell KR. Accuracy of mild traumatic brain injury diagnosis. Arch Phys Med Rehabil 2008;89(8):1550–5.
[33] Stiell IG, Wells GA, Vandemheen K, Clement C, Lesiuk H, Laupacis A, et al. The Canadian CT head rule for patients with minor head injury. Lancet 2001;357 (9266):1391–6.
[34] Meares S, Shores EA, Taylor AJ, Lammél A, Batchelor J. Validation of the Abbreviated Westmead Post-traumatic Amnesia Scale: a brief measure to identify acute cognitive impairment in mild traumatic brain injury. Brain Inj 2011;25(12): 1198–205.
[35] Theadom A, Hardaker N, Bray C, Siegert R, Henshall K, Forch K, et al. The brain injury screening tool (BIST): tool development, factor structure and validity. PLoS One 2021;16(2):e0246512.
[36] Silverberg ND, Iverson GL, ACRM Brain Injury Special Interest Group Mild TBI Task Force members, Cogan A, Dams-O-Connor K, Delmonico R, et al. The American Congress of rehabilitation medicine diagnostic criteria for mild traumatic brain injury. Arch Phys Med Rehabil 2023;104(8):1343–55.