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Paediatric Head Injury and Traumatic Brain Injury

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Abstract

Aim

To determine prevalence of head injury presenting to paediatric emergency departments (PEDs) and characterise by demographics, triage category, disposition neuroimaging or re-attendance.

Methods

Presentations in 2014 and 2015, with diagnoses of head injury, intracranial bleed, skull fracture including single or re-attendances within 28 days post head injury to all national PEDs, were analysed. Demographics, triage score, imaging rate, admission, mechanisms and representation rate were recorded.

Results

Head injury was diagnosed in 13,392 of 224,860 (5.9%), median (IQR) age 3.9 (1.4 - 8.3) years. Regionally 3% of children <5 years attend each year. The total admitted/transferred was 10.8% (n=1460). Neuroimaging rate was 4.3% (n= 570). Falls predominated. Sport accounted for 12.2%.

Conclusion

One in twenty children PED presentations are head injury, over half in preschool children. A sizeable number were symptomatic reflected by admission, transfer, imaging or re-attendance. Observational management was favoured over imaging reflected in the higher admission versus imaging rate.

Introduction

Head injury is a common presentation to the Paediatric Emergency Department (PED), ranging from trivial soft tissue injuries to traumatic brain injury (TBI), resulting in neuro-disability or death. Concussion, a mild Traumatic Brain Injury (mTBI), is more likely to be under-diagnosed in young children due to their inability to report symptoms. Mild TBI results from an impact to the body that is directly or indirectly transmitted to the brain[1] and accounts for 90% of TBI internationally. A complex pathophysiological process ensues with symptoms affecting a child's ability to function physically, cognitively and psychologically. An admission for paediatric head injury overnight doubles the risk of a subsequent diagnosis of paediatric attention deficit hyperactivity disorder in 5-10 year olds[2]. In the U.S. between 2001-2005 it was estimated that half of mTBI in the 8-19y age group at Emergency Departments were sporting related[3]. Ireland has a different sporting profile to the U.S, yet Irish youth rugby players have an 6.6% incidence of concussion annually [4]. Concussion is emerging as the most common injury in amateur rugby,[5] above sprains and other injuries. The mechanisms of mTBI (concussion) in children as a population presenting to PED is yet uncharacterized.

The Centres for Disease Control in 2018 emphasised the need to select children at risk of ongoing symptoms from mTBI early, for rehabilitation[1]. In the US paediatric diagnoses of mTBI in Paediatric Emergency Department (PED)s have doubled in 10 years.[6] Children with learning disabilities take longer to recover from mTBI[7] and adolescents are at a higher risk than adults for ongoing symptoms. Exercise over traditional rest is an important part of recovery [1,8].

Internationally there has been an effort to reduce the numbers of children with head injury undergoing computerised tomography (CT) because of ionizing radiation[9 10]. Korea estimates an incident ratio risk of 1.65 for all causes of cancer for people who underwent CT brain in childhood[11]. In 2009, the Paediatric Emergency Care Applied Research Network (PECARN) published a clinical prediction rule for identifying children at very low risk of clinically important traumatic brain injuries[12]. This study had a CT rate of 35%. The CT rate for head injuries, and the threshold for scanning children in Ireland is previously undocumented. This study aimed to define the population attending the national paediatric emergency service (3 PED in the greater Dublin area) detailing the severity of injury by triage category, neuroimaging, disposition and unscheduled re-attendances.

Methods

A retrospective analysis was performed of the *Symphony* Emergency Department Information System (EDIS), the electronic system that records emergency department activity, and the National Integrated Medical Imaging System (NIMIS) from January 1st 2014 to December 31st 2015. The patients requiring CT imaging were matched on EDIS by the medical record number and date of birth. Ethical approval was received from the Ethics boards of the hospitals.

The annual census for the 3 national PEDs all in the greater Dublin area, is 112,430. National Paediatric population data for the region was acquired from the 2016 national Irish census. For the purpose of analysis, the area served by the three PEDs had a population of 1.9 million people.

EDIS search terms used, include diagnoses of head injury, intracranial bleed, skull fracture and head injury re-attendances, as concussion was not a diagnosis recorded by the system. All sites utilise the Irish Childrens' Triage System (ICTS) the national paediatric triage tool, incorporating vital signs, mechanism of injury, elements of the history and comorbidities to generate a triage category with 1-5 scale, category 1 being most critical[13].

Table 1: Irish Children's Triage Category for Head Injury

Triage Category	Features
1	Airway compromise Respiratory failure / respiratory arrest Unresponsive / Glasgow Coma Scale Score (GCS) ≤ 12 Currently seizing Abnormal age-related vital signs ≤ 2 standard deviations below range, or one standard deviation below if < 1 year for respiratory rate or pulse Penetrating Injury
2	Abnormal age-related vital signs > 2 standard deviations above range or < one standard deviation below range for pulse or respiratory rate Severe hypertension Glasgow Coma Scale Score (GCS) 13-14 Severe pain (7-10/10) Mechanism of injury as per major trauma including those described in NICE History of bleeding disorder Significant medical or surgical history Ventriculo-peritoneal shunt Persistent vomiting New neurological symptoms History of loss of consciousness ≥ 30 seconds Blood or serous fluid in nose or ear(s) Bruising around the eyes or behind ears History of blurred vision or seizure Patient on spinal precautions Large scalp laceration with pulsatile bleeding Boggy temporal, parietal or occipital swelling
3	Abnormal age-related vital signs up to two standard deviations above normal for pulse and heart rate and one standard deviation below for respiratory rate in children > 1 year Moderate hypertension Moderate pain (4-6/10) Inconsistent history History of loss of consciousness < 30 seconds Amnesia Infant < 1 year
4	Mild pain (1-4/10) No loss of consciousness / no amnesia
5	Problem > 24 hours with no acute symptoms No vomiting

Table 1: Compiled from Irish Children's Triage System vital signs specific triage scoring and specific head injury triage scoring guidelines[13].

Symptomatic head injuries included patients admitted for observation, requiring imaging, or transferred to specialist paediatric neurological centres as well as those re-attending with related issues within 28 days post head injury. Age groups were subdivided as follows: infant (<1 year), Preschool (1- 4.9 years), Primary school age (5-11.9 years) and Secondary School age (12-16 years). Re-presentation episodes were manually checked. The location/mechanism could be identified in the triage record at a single site with full electronic record. The final mechanism analysis was of this dataset only. The other two sites had paper documentation system that yielded unacceptably high missing values. Mechanisms

were categorized and sports and recreation subdivided. Statistical analysis was carried out with IBM SPSS Statistics for Windows (V.24, Armonk, New York, USA). Data were expressed as median and interquartile ranges for the quantitative variables and as numbers and percentages for the categorical variables.

Results

Demographics

Ireland has a population of 4.8 million with 1.2million aged 0-16y. The area served by the three PEDs had a population of 1.9 million people representing 39% of the population with a similar age distribution. The annualised presentation rate was 3.4%, 2.8%, 1% and 0.8% of under one, 1- 4.9 years, 5-11.9 years and 12-16 years respectively. Overall 1.5% of the paediatric population present to PED yearly with head injury.

From January 2014 to December 2015, 13,392 of 224,860 (5.9%) of presentations to Dublin PEDs had diagnoses of head injury, intracranial bleed, or skull fracture in children aged 0-16y. There were 85,000, 71,444 and 68416 in the three sites. Mechanism was identifiable in 51.9% of the pooled data, and in 97.4% of the 4,253 head injuries in the only centre with electronic-based triage record. Similar mechanisms were reflected in the pooled data. Males accounted for 73% of head injuries from 12-16y. This male predominance emerged after infancy. Half of head injuries are triaged as category four or five [13]. The majority were self-referrals and all age-groups spent a median (IQR) of 3.5 (+/- 2.5) hours in the department.

Table 2: Demographics, Arrival and treatment pathway of TBI presentations.

	Infant (< 1 y)	*Preschool (1-4y)*	*Primary School (5-12y)*	*Adolescent (12-16y)*	*All*
Presentations	1707 (12.7%)	6022 (45%)	3674 (27.4%)	1989 (14.9%)	13392
Male sex	870 (51%)	3543 (58.8%)	2481 (67.5%)	1448 (72.8%)	8342 (62.3%)
Arrival by Ambulance*	98 (10.4%)	336 (10.8%)	249 (12.2%)	210 (17.7%)	893(12.3%)
GP Referral source *	112 (11.8%)	431 (13.9%)	332 (16.2%)	272 (22.9%)	1147 (15.9%)
Triage Category					
1	2 (0.1%)	17 (0.3%)	11 (0.3%)	10 (0.5%)	40 (0.3%)
2	273 (15.9%)	835)13.9%)	672 (18.3%)	472 (23.7%)	2252 (16.8%)
3	961 (56.3%)	1551 (25.8%)	1096 (29.8%)	762 (38.3%)	4370 (32.6%)
4 or 5	471 (27.6%)	3614 (60%)	1890 (51.4%)	743 (37.4%)	6718 (50.1%)
Time in dept: h	3.99	3.33	3.46	3.7	3.5 (+/-2.5)
Admitted to ward	396 (22.3.%)	350 (5.2%)	342 (7.2%)	196 (8.35%)	1123 (8.4%)
Admitted ICU	1 (0%)	3 (0%)	4 (0.1%)	0	8 (0.1%)
T/F to Neurosurgery	13 (0.8%)	36 (0.6%)	74 (2%)	30 (1.5%)	153 (1.1%)
Discharged home	1300 (76.2%)	5630 (93.5%)	3285 (89.4%)	1715 (86.2%)	11930(89.1%)
Died	0	0	0	1	1
OPD/ Review	8 (0.5%)	33 (0.6%)	34 (0.9%)	61 (3%)	136 (0.3%)
Neuroimaging	40 (2.3%)	151 (2.5%)	203 (5.5%)	176 (8.8%)	570 (4.3%)
Re-presented	31 (%)	119 (2%)	111 (3%)	130 (6.5%)	391 (2.9%)

**Data taken from only two centres. % expressed over denominator of total presentations to these two hospitals. ICU; intensive care unit, OPD; out-patients department.*

Mechanisms

Presentation incidence peaked in September. Falls were predominant (n=1886; 45.5%). Injuries at school comprised 7.8% of all injuries. In children under 1 year old there were 27 falls from "changing tables", with five "walker" related head injuries. In school age children (5-11.9yr olds), school injuries account for 209 (17.8%) compared to 146 sports related injuries and 145 recreational injuries (Table 3). Overall the highest incidence of sporting head injuries was in rugby (n=177, 26.7%) but scooters (n=61) and trampolines (n=49) accounted for a share of recreational injuries.

Table 3: Aetiology of Head Injuries presenting by age to single site with electronic record.

	Infant < 1 year n = 438	*Preschool (1-4y) n = 1849*	*Primary School (5-12y)* n = 1215	*Adolescent (12-16y)* n = 751	***All*** n = 4253
Known mechanism	**431 (98.4%)**	**1811 (97.9%)**	**1174 (96.6%)**	**726 (96.6%)**	**4142 (97%)**
Road traffic accident	5 (1.2%)	41 (2.3%)	43 (3.6%)	23 (3.2%)	112 (2.6%)
Assault	0	0	5 (0.4%)	54 (7.4%)	59 (1.4%)
Direct blow	55 (12.7%)	514 (28.4%)	301 (25.6%)	104 (14.3%)	974 (23.5%)
Fall (all falls)	371 (86%)	1113 61.5%)	325 (27.6%)	77 (10.6%)	1886 (45.5%)
School Injury	0	43 (2.4%)	209 (17.8%)	72 (9.9%)	324 (7.8%)
Recreational	0	46 (2.5%)	61 (5.2%)	18 (2.5%)	125 (2.9%)
Sports Related Injury	0	54 (3.5%)	230 (19.4%)	378 (52%)	662 (15.9%)
Team Sports		***10 (18.6%)***	***109 (47.2%)***	***291 (76.9%)***	***410 (61.8%)***
Basketball		2 (3.7%)	5 (2.2%)	8 (2.1%)	15 (2.3%)
Cricket			1 (0.4%)		1 (0.2%)
Football		7 (13.%)	64 (27.7%)	83 (22.0%)	154 (23.2%)
Gaelic games			14 (6.1%)	33 (8.7%)	47 (7.1%)
Hockey		1 (1.9%)	1 (0.4%)	14 (3.7%)	16 (2.4%)
Rugby			24 (10.4%)	153 (40.5%)	177 (26.7%)
Individual Sports		***44 (79.5%)***	***114 (49.8%)***	***71 (18.8%)***	***228(34.5%)***
Bike		36 (66.7%)	84 (36.8%)	35 (9.3%)	155 (23.5%)
Golf		2 (3.7%)	9 (3.9%)	2 (0.5%)	13 (2.0%)
Horse-riding		5 (9.3%)	14 (6.1%)	18 (4.8%)	37 (5.6%)
Martial Arts			4 (1.7%)	7 1.9%)	11 (1.7%)
Tennis			1 (0.4%)		1 (0.2%)
"Match"			2 (0.9%)	9 (2.4%)	11 (1.7%)
Undefined					
"Sport"		1 (1.9%)	7 (3.0%)	16 (4.2%)	24 (3.6%)

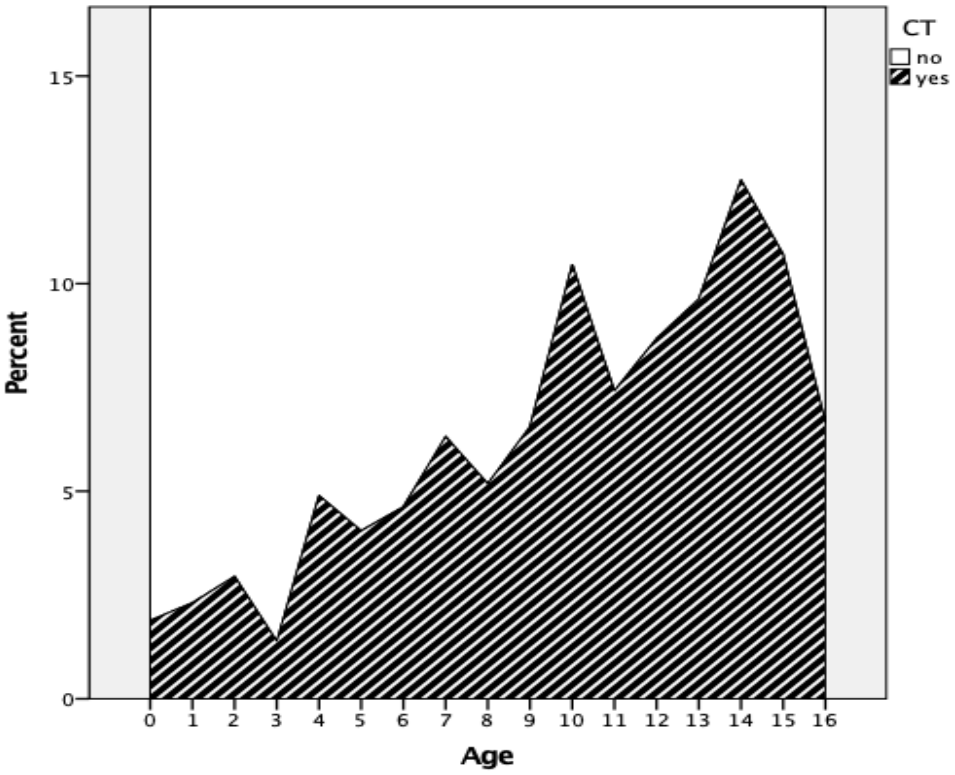
Percentages expressed as proportion of age category

Use of diagnostic imaging and observation

CT brain was performed on 570 (4.3%) and ranged from 3.5% to 6.2% between centres. Only 55% of the most critical category ICTS category 1 were imaged. Of category 2, 3 and 4 or 5, 11.5%, 4.0% and 1.7% were imaged. The likelihood of CT increases with age, 2.3% of children under 5yrs and 8.8.% of the adolescents (Figure 1). When patients re-presented

they were more likely to be imaged 87/391 (22.2%). In total, 341 of children imaged were discharged home from PED without an admission, 26 were discharged to OPD follow up. More than half are neither admitted nor followed-up within the institution after imaging.

Figure 1: Percentage Of Children Undergoing CT Imaging By Age.



Disposition

The total admission rate was 8.4% with variability between sites. The highest admission rates were in the under 1 year age group (22%). Child protection safeguarding policies encourage admission for observation and child protection review for head injuries in children under one. With the under 1 age group removed 6.3% of 1-16 year olds were admitted. Overall there were 1081 children admitted without imaging for observation and only 13.9% of all admission's had imaging. 133 (<1%) were referred for review or outpatient clinic after initial presentation, 44 were referred onwards after representation (11.3% of re-attendances). Reattendances were checked for the first month and the majority of these re-attendances, (80%; n=391), returned within the first seven days.

Discussion

Head injury makes up for a large number of PED presentations that are low acuity, non-urgent as classified by the Irish Children's Triage Tool. The majority occurred in the preschool and pre-verbal population. Males accounted for 57.7%, is consistent with previous reports of higher injury for head injury in boys > 5year old[14] but we saw an increase in the proportion from even 1 year of age. Accidents at school made up the majority of injuries in the 5-12y age group. Anecdotally playgrounds have a confined space with a surface that is often concrete and may represent the only opportunity for a sedentary generation of children to engage in any play[15]. Falls and direct blows account for 69% of

injuries, with sport accounting for only 12.2% of all PED head injuries. In adolescence, boys represent 70%, half with sport-related injury, with 40% from rugby, but rugby is 4.3% overall. Rugby players may be self-selecting due to awareness surrounding concussion. Due to the limitations of the current data surveillance system, head injury was not subdivided into degrees of severity by diagnosis coding, but by triage category, requirement for admission or imaging. There is no validated assessment scoring system[1,16] for the majority of presentations, in children under 5 years.

Overall the number undergoing imaging was remarkably low (4.3%) compared to international studies. The Paediatric Research in Emergency Department International Collaborative (PREDICT) Australian and New Zealand cohort reports a 10% rate of imaging in a similar population[17]. In the US it is 20% in general and 13% in dedicated paediatric emergency departments[18]. In our study minimal numbers of lower category patients were imaged. The Australasian Paediatric Head Injury Rules study had a rate of 10% while excluding only trivial facial injuries[17]. Applying strict imaging rules could increase our modest rate of CT. Colvin et al reported a 66% CT rate in ED presentations in the US, citing that the cost burden of admission being greater than imaging[6]. It is important to see that children are observed in their management, when safe to do so, regardless of costs, if it prevents avoidable ionising radiation. With each hour of admission, the need for CT decreases[19]. A recent study reinforces a practice of not imaging children with only isolated vomiting[20]. Observation in these children, before determining need for CT is appropriate.

In our institutions a wait and see approach was employed, as seen by lower imaging rates with higher admission rate. In ED space is at a premium. At the time of this study no short stay observational unit was available and the majority of children were admitted to wards without imaging. Older children were more likely to be imaged. This phenomenon has been seen previously[18]. It is difficult to say whether this is due to increased symptoms of mTBI in adolescence[1] prompting imaging or caution with radiation in younger children.

A sizeable proportion of children with head injury (8.4%) required admission. There is a calculated assumption that children who required imaging, admission (in any child over one year) or any return in the following days, with the same presentation had symptoms worthy of a diagnosis of mTBI. This amounts to 9.5% of the cohort. Few children are referred onward for further assessment; this is likely due to the lack of any formalised local or national paediatric facility for mTBI. The Center for Disease Control (CDC) require that children with premorbid conditions, or risk factors for prolonged symptoms have ongoing assessments. The guidance on paediatric mTBI recommended a review of children with ongoing symptoms beyond 7-10 days, and referral to a specialist symptoms where persist beyond a month[16]. Re-presentations in our study occurred within a week of their initial visit, when symptoms should be expected to persist. Adolescence, particularly in girls is a risk factor for prolonged symptoms[7]. Those who did represent had an increased rate of neuroimaging than first time presentations.

This study is representative only of PED presentations, it did not capture if children presented or re-presented to the GP. In the USA <10% of all mTBI present to ED, with older children more likely to attend primary care[21]. This age-group may be under-represented by only including PED attendances.

To the best of our knowledge this was the first study describing paediatric head injury in Ireland. The three hospitals represent the greater Dublin population and serve almost 40% of the national age group under 16 years. The triage categories for head injury are standardised and robust. While head injury is an acute presentation, chronic and disabling symptoms may be prevented by arranging timely follow-up for high risk patients[1, 22]. While older children are sometimes referred to adult services, no formalised pathway exists within the paediatric services to follow cases where symptoms do not resolve whose needs are best met outside the PED. It is vital that this information on head injuries is gathered to plan provision of services within paediatrics and a formalised clinical pathway for post concussive syndrome.

Declaration of Conflicts of Interest:
None to declare.

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References:

1. Lumba-Brown A, Yeates K, Sarmiento K, et al. Centers for disease control and prevention guideline on the diagnosis and management of mild traumatic brain injury among children. JAMA pediatrics 2018:e182853. doi: 10.1001/jamapediatrics.2018.2853
2. Narad ME, Kennelly M, Zhang N, et al. Secondary Attention-Deficit/Hyperactivity Disorder in Children and Adolescents 5 to 10 Years After Traumatic Brain Injury. JAMA pediatrics 2018;172(5):437-43. doi: 10.1001/jamapediatrics.2017.5746 [published Online First: 2018/03/20]
3. Bakhos LL, Lockhart GR, Myers R, et al. Emergency department visits for concussion in young child athletes. Pediatrics 2010;126(3):e550-6. doi: 10.1542/peds.2009-3101 [published Online First: 2010/09/02]
4. Delahunty SE, Delahunt E, Condon B, et al. Prevalence of and attitudes about concussion in Irish schools' rugby union players. The Journal of school health 2015;85(1):17-26. doi: 10.1111/josh.12219 [published Online First: 2014/12/03]
5. Yeomans CK, I.C. Cahalan, R. Warrington, G, Harrison, A. Hayes, K. Lyons, M. Campbell, M.J. Glynn, L.G. Comyns, T. The Epidemiology of Match Injury in Irish Amateur Rugby Union. Health Research Institute Research Symposia. Ireland, 2018.
6. Colvin JD, Thurm C, Pate BM, et al. Diagnosis and acute management of patients with concussion at children's hospitals. Archives of disease in childhood 2013;98(12):934-8. doi: 10.1136/archdischild-2012-303588 [published Online First: 2013/07/16]
7. Iverson GL, Gardner AJ, Terry DP, et al. Predictors of clinical recovery from concussion: a systematic review. British journal of sports medicine 2017;51(12):941-48. doi: 10.1136/bjsports-2017-097729 [published Online First: 2017/06/02]
8. Thomas DG, Apps JN, Hoffmann RG, et al. Benefits of strict rest after acute concussion: a randomized controlled trial. Pediatrics 2015;135(2):213-23. doi: 10.1542/peds.2014-0966 [published Online First: 2015/01/07]
9. Jennings RM, Burtner JJ, Pellicer JF, et al. Reducing Head CT Use for Children With Head Injuries in a Community Emergency Department. Pediatrics 2017;139(4) doi: 10.1542/peds.2016-1349 [published Online First: 2017/03/04]
10. Organization Wh. Communicating radiation risks in paediatric imaging: information to support health care discussions about benefit and risk. 2016
11. Hong J-Y, Han K, Jung J-H, et al. Association of Exposure to Diagnostic Low-Dose Ionizing Radiation With Risk of Cancer Among Youths in South Korea. JAMA Netw Open 2019;2(9):e1910584-e84. doi: 10.1001/jamanetworkopen.2019.10584
12. Kuppermann N, Holmes JF, Dayan PS, et al. Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. Lancet (London, England) 2009;374(9696):1160-70. doi: 10.1016/s0140-6736(09)61558-0 [published Online First: 2009/09/18]

13. Geary UW, M. McCarthy, G. http://emnow.ie/wordpress/wp-content/uploads/2015/03/National-Emergency-Medicine-Programme-Irish-Childrens-Triage-System-June-2016.pdf 2016 [
14. Pearson J, Jeffrey S, Stone DH. Varying gender pattern of childhood injury mortality over time in Scotland. Archives of disease in childhood 2009;94(7):524-30. doi: 10.1136/adc.2008.148403
15. Williams JT, M, Morgan, M. Quail, A. Symth, E. Murphy, D, O'Mahony, D. Growing Up in Ireland: The lives of 13-year-olds. In: Institute EaSR, ed. Dublin: Stationary Office, 2018.
16. Hingley S, Ross J. Guidelines for diagnosing and managing paediatric concussion: Ontario Neurotrauma Foundation guideline. Archives of disease in childhood Education and practice edition 2016;101(2):58-60. doi: 10.1136/archdischild-2014-307252 [published Online First: 2015/08/25]
17. Babl FE, Borland ML, Phillips N, et al. Accuracy of PECARN, CATCH, and CHALICE head injury decision rules in children: a prospective cohort study. The Lancet 2017;389(10087):2393-402. doi: https://doi.org/10.1016/S0140-6736(17)30555-X
18. Blackwell CD, Gorelick M, Holmes JF, et al. Pediatric head trauma: changes in use of computed tomography in emergency departments in the United States over time. Annals of emergency medicine 2007;49(3):320-4. doi: 10.1016/j.annemergmed.2006.09.025 [published Online First: 2006/12/06]
19. Schonfeld D, Fitz BM, Nigrovic LE. Effect of the duration of emergency department observation on computed tomography use in children with minor blunt head trauma. Annals of emergency medicine 2013;62(6):597-603. doi: 10.1016/j.annemergmed.2013.06.020 [published Online First: 2013/08/06]
20. Dayan PS, Holmes JF, Atabaki S, et al. Association of traumatic brain injuries with vomiting in children with blunt head trauma. Annals of emergency medicine 2014;63(6):657-65. doi: 10.1016/j.annemergmed.2014.01.009 [published Online First: 2014/02/25]
21. Arbogast KB, Curry AE, Pfeiffer MR, et al. Point of Health Care Entry for Youth With Concussion Within a Large Pediatric Care Network. JAMA pediatrics 2016;170(7):e160294. doi: 10.1001/jamapediatrics.2016.0294 [published Online First: 2016/06/01]
22. Zemek R, Barrowman N, Freedman SB, et al. Clinical Risk Score for Persistent Postconcussion Symptoms Among Children With Acute Concussion in the ED. Jama 2016;315(10):1014-25. doi: 10.1001/jama.2016.1203 [published Online First: 2016/03/10]