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Epidemiology of paediatric moderate and severe traumatic brain injury in the Netherlands

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ABSTRACT

Introduction: Traumatic brain injury (TBI) is the main cause of death in children around the world. The last Dutch epidemiological study described the incidence over 10 years ago. Mechanism of injury seems to change with the age of the child, therefore it is important to appreciate different age groups. To be able to lower the impact of childhood TBI, an understanding of current incidence, mechanism of injury and outcome is necessary.
Methods: A nationwide retrospective cohort study was conducted. The Dutch National Trauma Database was used to identify all patients 18 years and younger who were admitted to a Dutch hospital with moderate-severe TBI (Abbreviated Injury Score≥3) in the Netherlands, from January 2015 until December 2017. Subanalyses were done for different age groups.
Results: In total, 1413 patients were included, of whom 5% died. The incidence rate of moderate-severe TBI was 14/100,000 person years. Median age was 10.4 years. Largest age group was patients <5 years, incidence rate was highest in patients ≥16 years. Falls were more common than road traffic accidents (RTA), but RTAs occurred far more frequently amongst children over 10. RTAs predominantly consisted of bicycle accidents. Mortality rates increased from youngest to oldest age groups, as did the chances of a Glasgow Outcome Scale score of 3.
Conclusion: Paediatric moderate-severe TBI represents a significant problem in the Netherlands. Falls are the most common mechanism of injury amongst younger children and RTAs amongst older children. Unique for the Netherlands is the vast amount of bicycle accident related injuries.

1. Introduction

Traumatic brain injury (TBI) amongst children is quite common, with estimates of three million affected children globally every year and 35,000 annual hospitalisations in the United Kingdom [1,2]. A New Zealand birth cohort starting in 1977 showed that before the age of 26, 151 people (1%) had been admitted to hospital for TBI [3]. A major trauma centre in London identified 116 children with TBI proven on CT in two years [2]. In one area in the Netherlands, 130 patients were identified to have moderate or severe brain injury in 2008 and 2009 [4]. Distinct comparison of those epidemiological reports is difficult as classification of severity of TBI varies as do study design, cohort type and cohort size [1].

Defining the different degrees of TBI has proven difficult, leading to different definitions in most studies. In London, they identified clinically important TBI when the CT head showed abnormalities, in the Netherlands the Glasgow Coma Scale (GCS) was used to distinguish different grades of injury, and New Zealand used a combination of both [2–4]. When the incidence of childhood TBI in Europe was investigated, up to 90% of children had no abnormalities on the CT scan of the head [1]. In research investigating trauma

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to other areas than the brain, the Abbreviated Injury Score (AIS) is commonly used. Using this score, at least allows for comparison to injuries in other regions of the body. As moderate and severe TBI more often lead to mortality or disability than mild TBI, it would also be beneficial to identify them correctly, as especially the GCS can misidentify mild TBI as moderate or severe due to complicating factors such as intubation and sedation [5,6].

Moreover, TBI is the main cause of death in children around the world. Two of the peaks in the trimodal distribution described by the Centres for Disease Control and Prevention (CDC), are in children [2,7]. However, paediatric mortality rates after moderate and severe TBI are lower than for adults with rates as low as 5–16% [2,8].

Recent studies investigating epidemiology of paediatric TBI for different age groups are scarce. The last Dutch epidemiological study describes the incidence over 10 years ago [4]. In keeping with adult studies, most paediatric studies reveal falls and RTAs as the most frequent mechanism of injury [9]. However, children are passengers rather than drivers when it comes to motor vehicles and are more often involved as a pedestrian [9]. Furthermore, in high income countries, the incidence of road traffic accidents seem to have decreased over the last decades due to preventative measures [10].

To be able to lower the impact of childhood TBI, an understanding of current incidence, mechanism of injury and outcome is necessary. This would help to identify on which areas research and prevention methods should focus. Therefore, we investigated the incidence, mechanism of injury, demographics and outcome of moderate and severe TBI requiring hospital admission amongst children of 18 years and younger, with a subanalysis of different age groups.

2. Materials and methods

A nationwide retrospective cohort study was performed using the Dutch Trauma Registry (DTR). The DTR was founded in 2007 and is maintained by the Dutch Trauma Network of Acute Care with the general purpose of monitoring trauma care with a standardised registry and to ensure high quality care for severely injured patients. The DTR covers approximately 99% of all hospitals in the Netherlands and prospectively collects data on all trauma patients who are admitted to the hospital after presenting to the Accident and Emergency department (A&E), within 48 h after trauma. Patients presented to A&E by pre-hospital Emergency Medical Services, as well as by self-admission, are included in the DTR. Patients declared dead on arrival, who are discharged home from A&E, and those admitted to the hospital for reasons other than their traumatic injury were excluded [11]. In order to determine the incidence rate of TBI requiring hospital admission, national demographic data were obtained using the Dutch Population Register from the *Central Bureau of Statistics* [12].

All patients aged 18 years and younger admitted to the hospital between January 2015 and December 2017 with moderate or severe TBI were identified using Abbreviated Injury Scale codes for traumatic brain injury. The AIS is a widely accepted anatomically based scoring system to grade injuries from mild to maximal (almost certainly leading to death) on a scale from one to six and coders can use data from the patient's records, including imaging and surgical reports, to assign a score, using a supplied standardised guideline [13]. Combined AIS scores are used to determine the Injury Severity Score (ISS). AIS scores as recorded in the DTR were calculated by data managers of the participating trauma centres as per ISS 08 [14]. Moderate to severe TBI was classified as an AIS of the head region (AIShead) of three or higher. Five different age groups were analysed separately: <3 years old, 3-<5 years old, 5-<10 years old, 10-<16 years old and children of 16–18 years old. The last group was analysed separately as this group is legally allowed to drive a moped and children can start driving lessons from age 16.5. To prevent inclusion of duplicate cases, all patients who required early transfers to another hospital were excluded.

The following baseline variables were obtained from the DTR: age at trauma, sex, American Society of Anesthesiologists (ASA) score, mechanism of injury, Glasgow Coma Scale Score, AIS scores for all body regions and Injury Severity Scores (ISS) scores.

The outcome variables obtained were frequency of involvement of the Mobile Medical Team (MMT), highest level of received care, hospital length of stay (H-LOS), ICU length of stay (I-LOS), mortality, and Glasgow Outcome Scale (GOS) score [15] at the time of hospital discharge. In the Netherlands, the MMT consists of a trauma surgeon or anaesthesiologist and a trained nurse to provide acute care on scene.

All variables were collected for all included patients and separately for the different age groups.

Data were analysed using descriptive statistics and presented as frequencies with percentages for categorical data, means with standard deviations (SD) for normally distributed continuous data, and medians with interquartile ranges (IQR) for non-normally distributed continuous data. The Shapiro-Wilk test and Quantile-Quantile plots were applied to detect deviations from the normal distribution. The incidence rate was calculated by dividing the total number of patients with TBI by the total Dutch population <19 years of age during the study period and for the corresponding ages for the different age groups. Incidence rates were expressed per 100,000 person-years. Statistical analyses were performed using SPSS statistical software (SPSS 23.0; IBM Inc., Armonk, NY, USA).

3. Results (Fig. 1a.)

In total, 1413 children were included in this analysis. In January 2017, 3,424,877 children were 18 years or younger, leading to an incidence rate of moderate and severe TBI of 14/100,000 person years.

Median age was 10.4 years and median ASA score was 1 (SD: 1-1). Falls were only slightly more common than RTAs. Median AIShead was 3 (SD: 2–4). Most children had a GCS of 15 if they had an AIShead of 3 (70%), this dropped to 44% if the AIShead was 5. Median ISS was 11 (SD: 9–18.5), and roughly one third had an ISS>16 (n = 472) (Table 1).

Highest level of care was most often the ward (n = 688; 51%). ICU admission was necessary for 451 patients (34%), median length of stay was 0 days (SD: 0–2). Median LOS in hospital was 3 days (SD: 2–6) (Table 2).

Bicycle accidents and accidents involving a pedestrian were most commonly the cause of a TBI that lead to mortality (both 17 children, 23% each), followed by passengers/drivers of a motorised vehicle (11 children, 15%). Most patients who survived their injuries had a GOS score of 5 (n = 511; 57%) (Table 2). Data are graphically summarised in Fig. 1a.

3.1. *Youngest age group (<3 years old) (Fig. 1b.)*

The youngest age group consisted of 293 children (21%). In 2017, 520,748 children of this age lived in the Netherlands, leading to an incidence rate of moderate and severe TBI of 19/100,000 person years.

Falls were far more common than RTAs. Median AIShead was 3 (SD: 3-3), median ISS 10 (SD: 9–16) and 20% of children had an ISS over 16 (n = 57). Most children had a GCS of 15 if they had an AIShead of 3 (81%), this dropped to 15% if the AIShead was 5. (Table 1).

Table 1
Baseline variables.

	ALL n = 1413	<3 years n = 293 (21%)	3-<5 YEARS n = 138 (9.8%)	5-<10 YEARS n = 258 (18%)	10-<16 YEARS n = 353 (25%)	≥16 YEARS n = 371 (26%)	p-value
DEMOGRAPHICS							
Incidence rate *person years*	14/100,000	19/100,000	13/100,000	9/100,000	10/100,000	20/100,000	
Median (IQR)							
Age	10.4 (3.9–16.2)						
N (%)^							
Female	533 (38)	107 (37)	54 (39)	103 (40)	145 (41)	124 (33)	0.245
CLINICAL CHARACTERISTICS							
Median (IQR)[a]							
ASA	1 [1–1]	1 [1–1]	1 [1–1]	1 [1–1]	1 [1–1]	1 [1–1]	
Missing	*257* [18]	*61* [21]	*27* [20]	*49* [19]	*62* [18]	*58* [16]	
ISS	11 (9–18.5)	10 [9–16]	10 [9–14]	10 [9–17]	13 [10–22]	16 [10–26]	<0.001
AISHead	3 [2–4]	3 [3–3]	3 [3–3]	3 [3,4]	3 [3,4]	3 [3,4]	
N (%)^							
Mechanism							<0.001
RTA	565 (44)	29 [11]	29 [23]	73 [32]	190 (58)	244 (73)	
Bicycle	291 (52)	13 (45)	15 (52)	43 (59)	136 (72)	84 (34)	
Pedestrian	75 [13]	7 [24]	8 [28]	19 [26]	25 [13]	16 [7]	
Motor-Vehicle	79 [14]	5 [17]	4 [14]	8 [11]	14 [7]	48 [20]	
Motorcycle	6 [1]	0 (0)	0 (0)	0 (0)	4 [2]	2 [1]	
Moped	104 [18]	0 (0)	1 [3]	3 [4]	8 [4]	92 (38)	
Fall	594 (47)	211 (83)	88 (71)	132 (57)	98 [30]	65 [19]	
Low height	319 (54)	103 (49)	45 (51)	70 (53)	66 (67)	30 (46)	
Missing	*142* [10]	*39* [13]	*14* [10]	*28* [11]	*26* [7]	*35* [9]	
AISHead							0.003[b]
3	998 (70)	223 (76)	110 (80)	189 (73)	228 (65)	238 (64)	
GCS 15	596 (70)	140 (81)	66 (73)	126 (75)	143 (65)	121 (61)	
4	253 [18]	45 [15]	19 [14]	42 [16]	75 [21]	72 [19]	
GCS 15	111 (51)	22 (65)	11 (50)	22 (54)	37 (54)	19 (35)	
5	172 [12]	25 [9]	9 [6]	27 [11]	50 [14]	61 [16]	
GCS 15	47 (44)	2 [15]	2 (50)	11 (58)	21 (50)	11(37)	
Missing GCS	*233* [16]	*72* [25]	*21* [15]	*29* [11]	*22* [6]	*89* [24]	
ISS>16	472 (33)	57 [20]	25 [18]	65 [25]	141 (40)	184 (50)	<0.001

IQR=Interquartile range, ASA = American Society of Anaesthesiologists score, RTA = Road Traffic Accident, AIShead = Abbreviated Injury Scale of the head region, ISS=Injury Severity Score.
[a] Mann-Whitney *U* test, ^Chi Square test (or Fisher exact if observed value < 5).
[b] Applicable to AIShead.

Highest level of care was more often the ward (n = 167; 61%). Roughly a quarter of children needed ICU admission (n = 68). Median length of stay in ICU was 0 (0–2) days, and 2 (SD: 2–4) days in hospital. Most patients who survived their injuries had a GOS score of 5 (n = 119, 63 (Table 2). Data are graphically summarised in Fig. 1b.

3.2. Children aged 3-<5 (Fig. 1c)

This was the smallest age group in this study, with 138 (9.8%) children. In 2017, 351,541 children of this age lived in the Netherlands, leading to an incidence rate of moderate and severe TBI of 13/100,000 person years.

Most common mechanism of injury was falls (n = 88; 71%). Median AIShead was 3 (SD: 3-3), median ISS 10 (SD: 9–14) and less than 20% had an ISS over 16 (n = 25). Most children had a GCS of 15 if they had an AIShead of 3 (73%), this dropped to 50% if the AIShead was 5 (Table 1).

Highest level of care was most often the ward (n = 85; 64%). Around a quarter needed ICU admission (n = 31). Median length of stay in ICU was 0 (0–1.75) days, and 2 (SD: 2–3) days in hospital. A GOS score of 5 (n = 58, 60%) was most frequent amongst patients who survived their injuries (Table 2). Data are graphically summarised in Fig. 1c.

3.3. Children aged 5-<10 (Fig. 1d)

This group consisted of 258 children (18%). In 2017, 929,180 children of this age lived in the Netherlands, leading to an incidence rate of moderate and severe TBI of 9/100,000 children.

Falls were more common than RTAs. Median AIShead was 3 (SD: 3–4), median ISS 10 (SD: 9–17) and 25% of children had an ISS higher than 16 (n = 65). Most children had a GCS of 15 if they had an AIShead of 3 (75%), this dropped to 58% if the AIShead was 5 (Table 1).

Highest level of care was most often the ward (n = 139; 56%), almost 30% was admitted to ICU (n = 72). Median length of stay in ICU was 0 (SD: 0–2) days, and 3 (SD: 2–4) days in hospital. Most patients who survived their injuries had a GOS score of 5 (n = 102; 54%) (Table 2). Data are graphically summarised in Fig. 1d.

3.4. Children aged 10-<16 (Fig. 1e)

A quarter of children were included in this age group (n = 353). In 2017, 1,185,949 children of this age lived in the Netherlands, leading to an incidence rate of moderate and severe TBI of 10/100,000 children.

RTAs were the most common trauma mechanism, falls accounted for 30% (n = 98). Median AIShead was 3 (SD: 3–4),

Table 2
Outcome variables.

	ALL n = 1413	<3 years n = 293 (21%)	3-<5 YEARS n = 138 (9.8%)	5-<10 YEARS n = 258 (18%)	10-<16 YEARS n = 353 (25%)	≥16 YEARS n = 371 (26%)	p-value
N (%)^							
MMT	280 [21]	29 [10]	18 [14]	54 [22]	80 [24]	99 [28]	<0.001
Missing	*57* [4]	*10* [3]	*7* [5]	*13* [5]	*14* [4]	*13* [4]	
Highest level of care							<0.001
ED	101 [8]	22 [8]	10 [8]	23 [9]	29 [9]	17 [5]	
Ward	688 (51)	167 (61)	85 (64)	139 (56)	155 (46)	142 (41)	
Theatre	40 [3]	3 [1]	0 (0)	6 [2]	12 [4]	19 [5]	
MC/HC	58 [4]	14 [5]	6 [2]	8 [3]	15 [5]	15 [4]	
ICU	451 (34)	68 [25]	31 [24]	72 [29]	123 (37)	157 (45)	
Missing	*75* [5]	*19* [6]	*6* [4]	*10* [4]	*19* [5]	*21* [6]	
Mortality	75 [5]	10 [3]	6 [4]	11 [4]	21 [6]	27 [7]	0.195
GOS							<0.001
2	6 [1]	0	0 (0)	1 [1]	2 [1]	3 [1]	
3	99 [10]	12 [6]	4 [4]	17 [9]	26 [10]	40 [14]	
4	402 (39)	57 [30]	35 (36)	68 (36)	107 (42)	135 (47)	
5	511 (57)	119 (63)	58 (60)	102 (54)	122 (47)	110 (38)	
Missing	320 [24]	95 [32]	35 [25]	59 [24]	75(23)	56 [16]	
Discharge location							0.001
Care/residential home	3 (0)	0 (0)	0 (0)	2 [1]	0 (0)	1 (0)	
Nursing home	3 (0)	0 (0)	0 (0)	0 (0)	2 [1]	1 (0)	
Usual place of	1027	227 (79)	108 (90)	188 (80)	251 (78)	253 (76)	
Residence	(80)	3 [1]		10 [4]	27 [8]	47 [14]	
Rehabilitation centre	88 [7]		1 [1]				
Other	164 [13]	46 [16]	11 [9]	34 [15]	42 [13]	31 [9]	
Missing	*53* [4]	*7* [2]	*18* [13]	*13* [5]	*10* [3]	*11* [3]	
Median (IQR) [a]							
LOS ICU in days	0 (0–2)	0 (0–2)	0 (0–1.75)	0 (0–2)	0 (0–3)	1 (0–3)	<0.001
Missing	*134* [9]	*36* [12]	*18* [13]	*22* [9]	*29* [8]	*29* [8]	
LOS Hospital in days	3 [2–6]	2 [2–4]	2 [2,3]	3 [2–4]	3 (2–6.25)	4 [2–10]	<0.001
Missing	*55* [4]	*18* [6]	*7* [5]	*13* [5]	*7* [2]	*10* [3]	

MMT = Mobile Medical Team, A&E = Accident and Emergency department, MC = Medium Care unit, HC= High Care unit, ICU= Intensive Care Unit, LOS = Length of Stay, GOS = Glasgow Outcome Scale.
[a] Mann-Whitney *U* test, ^Chi Square test (or Fisher exact if observed value < 5).

median ISS 13 [10–22] and 40% of children had an ISS higher than 16 (n = 141). Most children had a GCS of 15 if they had an AIShead of 3 (65%), this dropped to 50% if the AIShead was 5 (Table 1).

Highest level of care was most often the ward (n = 155; 46%), followed by ICU (n = 123; 38%). Median length of stay in ICU was 0 (SD: 0–3) days, and 3 (SD: 2–6.25) days in hospital. GOS score of 5 was most common amongst patients who survived their injuries (n = 122, 47%) (Table 2). Data are graphically summarised in Fig. 1e.

3.5. Children aged 16 and older (Fig. 1f)

Approximately a quarter of children were included in this age group (n = 371). In 2017, 624,459 people of this age lived in the Netherlands, leading to an incidence rate of moderate and severe TBI of 20/100,000, the highest amongst age groups.

RTAs were by far the most common trauma mechanism, falls accounted for 19% (n = 65). Amongst RTAs, mopeds were most frequently mode of transport. Median AIShead was 3 (SD: 3–4), median ISS 16 (SD: 10–26) and half of the patients had an ISS higher than 16 (n = 184). Most children had a GCS of 15 if they had an AIShead of 3 (61%), this dropped to 37% if the AIShead was 5. (Table 1).

Highest level of care was most often ICU (n = 157; 45%), followed by the ward (n = 142; 41%). Median length of stay in ICU was 1 (SD: 0–3) days, and 4 (SD:2–10) days in hospital. GOS score of 4 was most frequent amongst patients who survived their injuries (n = 135; 47%) (Table 2). Data are graphically summarised in Fig. 1f.

4. Discussion

Moderate and severe traumatic brain injury in the paediatric population is relatively common, with 1413 cases in 2015–2017 in the Netherlands. This leads to an incidence rate of 14/100,000 person years, which approaches the incidence of childhood cancers, which had an incidence rate of 17/100,000 person years in 2017 [16]. Children with moderate or severe traumatic brain injury were predominantly male, with a median age of 10.4 years old. Approximately one-fifth of children required pre-hospital assistance from the MMT. There was a mortality rate of 5%, as 75 children died. Children mostly made a good recovery before discharge, with a GOS score of 5 for 57% of patients.

Mechanism of injury varies with age and severity of injury. Whereas babies are more likely to suffer from falls out of parent's arms and toddlers from RTAs as a pedestrian on a driveway rather than as a passenger or driver, older children are more likely to sustain injuries from their own actions, such as sport-related accidents. RTAs are in general more common in older children as well [1,17,18]. In our cohort, a fall was most commonly the mechanism of injury for children <10 years old, for children >10 years old, this was an RTA. In the USA, over 182,000 children younger than four years old visited A&E with TBI as a result of a fall, however, only five per cent had to be admitted to hospital [19]. Literature also shows that deaths from RTAs, in which the victim is a pedestrian, are less frequent than when the victim is a passenger. However, these data are over 10 years old and we expect that improved adherence to

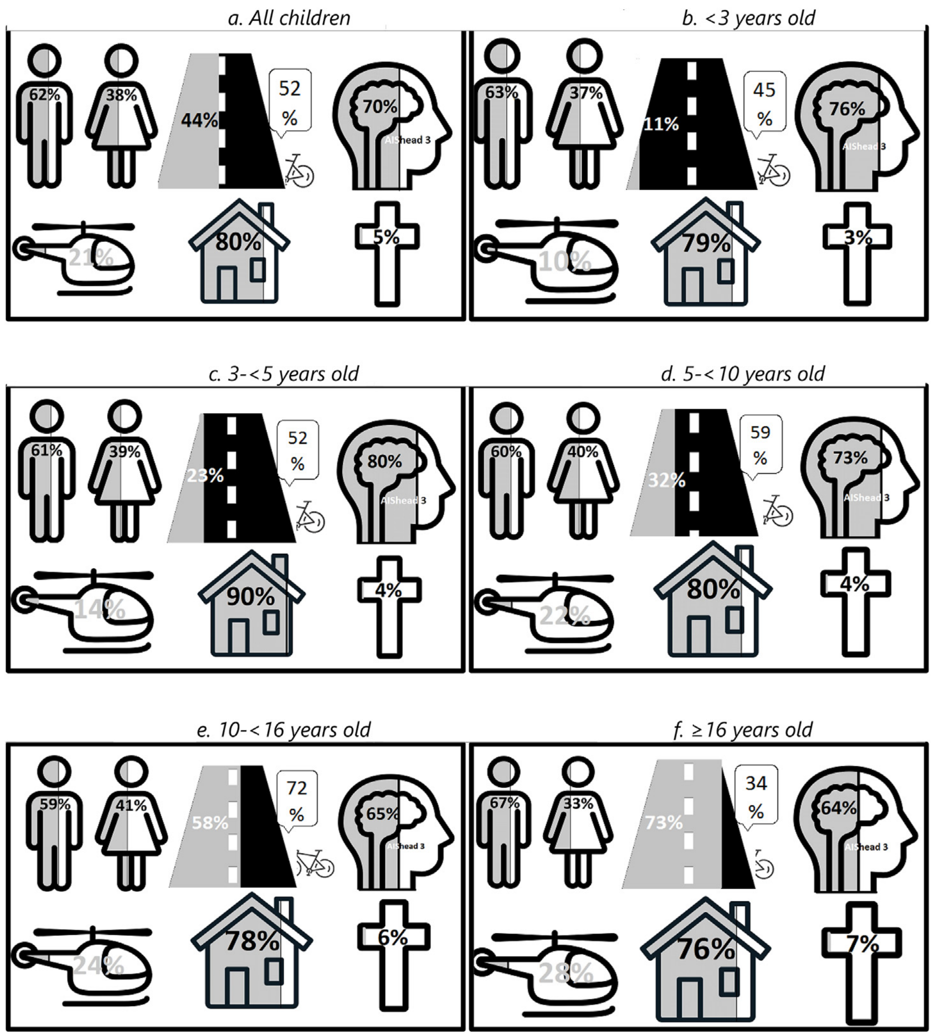

Fig. 1. (a–f). Left to right: Sex, Road Traffic Accident as trauma mechanism (of which bicycles), AIShead of 3, Retrieved by Mobile Medical Team, Home as discharge destination, Mortality.

safety precaution regulations might have changed this [18]. Especially since our limited data regarding paediatric deaths due to TBI seem to indicate otherwise. Unique to the Netherlands is the amount of bicycle-related TBIs, with almost 25% of all TBIs and over 50% of road traffic accidents. Amongst RTAs, the patient most frequently used a bicycle at time of injury, this was the moped for children of 16 years and older. In contrast, in London, only 1% of moderate and severe paediatric TBI was found in cyclists who were hit by a car or fell of the bicycle, as opposed to the 39% of patients who were hit by a car as a pedestrian [2]. Another European childhood TBI study found that only 25% of RTA victims were cyclists [9].

These outcomes suggest there are several possibilities for prevention of moderate and severe TBI. For example, discussions on mandatory helmet use for cyclists and moped drivers would be warranted, considering the high proportion of cyclists in our cohort. For mopeds with a speed limit of 45 km/h, the use of a helmet is already enforced by law, this is not the case for mopeds with a speed limit of 25 km/h, e-bikes and bicycles. As incidence rates were highest in the oldest age group, investigation regarding adherence to helmet laws amongst moped drivers could be helpful. Helmet use could potentially prevent TBI or at least lower the chances of severe TBI and seems to protect against skull fractures [20–22]. In another study from Nottingham, none of the 22 children who were admitted with primarily head injuries to a paediatric ICU wore a helmet [23]. In addition, further research is necessary to investigate the cause of paediatric falls as falls are the main cause of injury in our largest age group. This could help identify additional preventative measures.

Fortunately, it seems to be characteristic for children to have a higher chance of survival and improved recovery compared to adults. Survival rates of 95% amongst moderate and severe TBI exceed those of adults massively. This vast difference seems to be multifactorial, with differences in trauma mechanism and injury pattern, the rise of TBI amongst the comorbid elderly and difficulty in determining functional outcome for children [24]. As far as recovery goes, the high amount of GOS of 5 on discharge is encouraging. However, multiple studies report an impairment which the wide definition of the GOS of 5 might overlook [25,26]. This could be especially true for children, as it is difficult to predict what their development would have been like if they had not suffered from TBI. Furthermore, assessment of true functional outcome is even difficult for adults, as questionnaires and testing environments do not reflect challenges people face in their daily lives [26].

Severity of injuries seemed to increase with age, ranging from an ISS >16 in 20% of children <3–50% in children of 16 years and older. In addition, the incidence rate was also highest amongst the oldest age group. Median AIShead, however, was most often 3 in all age groups. There is controversy as to whether younger children have a bigger chance of mortality or other long-term sequelae due to TBI. Multiple studies conclude that the highest mortality rate is in the group of children <2 years, although we did not see this pattern in this study. Some hypothesise that this might be due to the higher contribution of non-accidental trauma in this age group, as these injuries lead to higher mortality rates [27]. Other studies show a higher mortality rate in older children, which is also true for our cohort, although not statistically significant. Hill et al. did not find any deaths in children <9 years old and van Pelt et al. noticed that older children were more likely to have severe TBI [2,4]. A study in the United States found that children between 15 and 19 years old were most at risk, although their population might not be comparable to ours, as 12% of deaths were caused by firearms [28]. As to consequences for functional outcome, it seems younger children are at higher risk, even though it was assumed for a long period that their brains would show more adaptability than those of older children [18,29].

A strength of this study is that it was nation-wide and data was retrieved from an established database. This allowed for analysis of clinically relevant factors. Furthermore, we used the AIS scores to establish whether injuries were moderate or severe, rather than mild. The fact that we used the AIS rather than GCS to classify TBI, could potentially be seen as a limitation. The large amount of patients with a GCS of 15 included in our database, may support the theory that AIShead overscores severity of TBI, rather than poor data collection [30]. Many studies use GCS scores to classify severity of TBI, but those are difficult to score on children and on a trauma population in general, as many patients receive some form of sedation and/or are intoxicated, although the latter solely applies to the older children [5].

When determining AIS scores, imaging is used, which is a more objective measurement. Unfortunately, the database did not allow for calculation of the Marshall or Rotterdam criteria, two widely accepted scores based on CT findings [31,32]. This would have allowed for more accurate comparison with other studies.

A limitation is that abusive head trauma was not classified as a separate category. There was a small number of patients classified to be the victim of assault, but we doubt that all victims were identified and classified correctly. One study even suspected 22.5% of children with an ICP meter of being the victim of abuse [27]. Another limitation is that some parameters were not collected for every patient, resulting in missing data and that we were unable to gather data on CT scan results, such as the location of a haematoma.

In conclusion, even though paediatric moderate and severe TBI is less common than TBI in adults and has a lower mortality rate, it is still a big problem. Highest incidence rates are amongst the oldest and youngest age groups, mortality rates and chances of moderate disability seem to increase with age. Falls are the most common mechanism of injury amongst younger children and bicycle injuries amongst the older children which is unique for the Netherlands. The strongest weapon to decrease incidence is prevention.

Declaration of interest

None.

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