Obtaining a History of Childhood Traumatic Brain Injury Using the Ohio State University TBI Identification Method to Elicit Adult Recall

Audrey McKinlay, PhD 1
John D. Corrigan, PhD 2
Jennifer A. Bogner, PhD 2
L. John Horwood, MSc 3

1 Melbourne School of Psychological Science, The University of Melbourne, Australia
2 Department of Physical Medicine and Rehabilitation, The Ohio State University, Columbus
3 Christchurch Health and Development Study, University of Otago, Christchurch, New Zealand

Corresponding Author: Audrey McKinlay, PhD, Melbourne School of Psychological Sciences, Psychology Clinic, The University of Melbourne, VIC 3010, Australia (audrey.mckinlay@unimelb.edu.au).

The authors declare no conflicts of interest.
Objective: To investigate the concordance between medically documented childhood traumatic brain injury (TBI) and recall of same by adults aged 35 years.

Participants: A total of 962 birth cohort members from the Christchurch Health and Development Study available at the 35-year follow-up.

Main Measures: Childhood TBI information prospectively collected yearly over ages 0 to 15 years as part of the Christchurch Health and Development Study. At age 35 years, cohort members were administered the Ohio State University TBI Identification Method (OSU TBI-ID) to elicit recall of TBIs with loss of consciousness (LOC).

Results: Ninety-four individuals reported 116 TBI events. Twenty-five TBI events resulting in LOC, 17 (68%) were recalled (true positives) and 8 (32%) were not recalled (false negatives). LOC was incorrectly recalled for 56 events (false positives), but 868 individuals correctly recalled no TBI event (no LOC). A further 35 events were (correctly) recalled for which a TBI had been recorded but no LOC (true negatives; 91.8%).

Implications: We evaluated the utility of the OSU TBI-ID to identify adult recall of childhood TBI with LOC occurring 19 to 35 years earlier. Most of the cohort accurately reported whether or not they had experienced a medically attended TBI with LOC, indicating that a positive result from the OSU TBI-ID provides useful screening information.

Key words: brain injury, cohort, head injury, longitudinal, memory, recall
INTRODUCTION

Children and young people frequently experience traumatic brain injury (TBI). Historically, the outcomes of childhood TBI were thought to have less impact than those experienced in adulthood due to the plasticity of the young brain. However, it is now generally accepted that early TBI, regardless of severity (mild to severe), can result in adverse outcomes that may be detectable into adulthood. These outcomes include increased rates of criminal and antisocial behavior and increased drug abuse. It is not surprising, therefore, that a number of studies have found offender populations to contain a disproportionate number of individuals with a history of TBI. It is likely that the cognitive problems associated with TBI will reduce the effectiveness of standard intervention programs aimed at reducing recidivism. Therefore, because the problems associated with TBI may be long-lasting and have a substantial cost for the individual and community, it is important that a reliable method is found to screen for individuals who may have a history of TBI to ensure interventions suitable for this population are employed to reduce ongoing problems.

The identification of these injury events, whether for treatment or research, is problematic. A review of medical files may be used, but this relies on the individual being seen by a healthcare provider, and many individuals with TBI do not seek treatment. Diamond et al. reported that treatment had not been sought for 61% of persons reporting TBI within a prison population. Moreover, in cases of multiple injuries, the medical file may record only the more overt injury, potentially obscuring the TBI if not the focus of treatment. Identification of early injuries from medical records is complicated even further because it necessitates recall of injuries that occurred many years earlier, requiring the individual to recall all healthcare providers from childhood in order to obtain the relevant medical records.

It is common for information about lifetime history of TBI to be collected via self-report. However, research has demonstrated that the general public are often confused about what constitutes a TBI event, so many do not report its occurrence. Moreover, the collection of lifetime history of TBI requires careful consideration regarding what questions are asked to elicit accurate data. As reported by Diamond et al., only 19% of individuals who reported a history of TBI when an in-depth interviewer instrument was administered also reported a history of TBI when a single screening question was used. Currently there is little information regarding the accuracy of adult recall of childhood TBI in the general population. As outlined earlier, it is often important to be able to identify TBI in groups of individuals for whom TBI is not the defining criteria—for example, prison, mental health, or school populations, where identification of TBI may lead to a different intervention approach.

The Ohio State University Traumatic Brain Injury Identification Method (OSU TBI-ID) is a standardized procedure to elicit the lifetime history of TBI for an individual. The OSU TBI-ID has been validated in a number of populations including the adult general population, prisoners, and those in treatment for substance use disorders.

The aim of the current study is to evaluate the accuracy of the OSU TBI-ID in identifying early instances of TBI with loss of consciousness (LOC) (0–15 years) recalled in adulthood (35 years old) by comparing recall with existing medical records. Only cases of medically attended TBI were included to enable accurate comparisons between childhood TBI events recalled at 35 years of age and TBI events where medical information was available.
PARTICIPANTS

The Christchurch Health and Development Study (CHDS) is a birth cohort of children born in the Christchurch region of New Zealand, initiated in 1977 and originally composed of 1265 children. These children represented 97% of all births occurring in Christchurch during the 3-month recruitment period for the study. Cohort members have been studied at birth, 4 months, 1 year, and at yearly intervals to age 16 years, then again at ages 18, 21, 25, 30, and 35 years. Data have been gathered using information from a combination of sources including parental interview, self-report, psychometric assessments, teacher questionnaires, medical records, and other official records. All data gathered as part of the study gained signed consent from the research participants. The research was granted ethics approval by the New Zealand Health and Disability Ethics Committee.

MEASURES

Information regarding medical treatment for TBI was collected in a number of ways. At each assessment from age 4 months to 15 years, comprehensive information was obtained on the child’s history of medical care including hospitalization and emergency department treatment since the previous assessment. All reports of medically attended events were verified against medical records. Medical record abstraction information from the CHDS archives was reviewed for descriptors of LOC including the following indicators: “LOC,” “unconscious,” “knocked out,” “suspected LOC,” “probably KOed.” Information regarding each medical attendance was reviewed to determine whether a TBI had taken place. The few instances where LOC occurred, but was not due to a TBI (e.g., seizure), were not included as recalled TBI. Falls were the most common mode of injury for the age group reviewed (see McKinlay et al. for full description of mode of injury).

Adult self-report of childhood TBI with LOC was determined using the OSU TBI-ID, a standardized procedure to elicit the lifetime history of TBI. The screen, which takes 3 to 5 minutes, first asks for a recollection of all injuries to the head or neck that required medical attention, followed by 4 questions focused on injuries to head or neck with mechanisms involving high velocity forces. For example, informants are asked about injuries to the head or neck from a motor vehicle crash, biking accident, horseback riding, falls, or fights. The occurrence of altered states of consciousness, nature of changes, and age at time of injury are then determined.

PROCEDURE

All members of the cohort who were available at the 35-year follow-up (962 individuals) were administered the OSU TBI-ID to determine adult self-report of TBI with LOC during childhood. The OSU TBI-ID was integrated into the full 35-year follow-up survey protocol.

STATISTICAL ANALYSIS
Counts and percentages were generated for adult recall of childhood TBI using the OSU TBI-ID and for medically recorded events of TBI with LOC. Data were used to calculate sensitivity, specificity, positive and negative predictive value, and positive and negative likelihoods to determine the concordance between medical record abstraction and adult recall using the OSU TBI-ID.

RESULTS

Results are discussed in terms of medical events, not individuals, as some individuals had more than one event. At the 35-year assessment, 962 individuals were available for follow-up. Ninety-four of these cohort members reported 116 medically attended TBI events (treated at the emergency department or admitted to hospital). Thus, a total of 984 event reports were included in the model (including those who reported no TBI event).

INSERT TABLE 1

OSU-TBI-ID results were compared to known historical TBI with LOC events, which were tabulated prior to the study. As shown on Table 1, 25 TBI events resulted in a medically recorded LOC. At 35 years of age, 17 LOC events (68%) were recalled and 8 LOC events (32%) were not recalled—true positives and false negatives, respectively. Medical records did not reflect LOC for 56 events (false positives). From those available for follow-up, 868 individuals recalled that they had experienced no TBI event and therefore no LOC. Furthermore, there were 35 events where no LOC was correctly recalled by individuals for whom a TBI event had been recorded. Recall from these 903 events (35 868) makes up the true negatives (91.8% of all events).

As shown in Table 2, sensitivity and specificity of adult recall for TBI can be calculated using these data. Positive predictive value of the OSU TBI-ID was low (23.29%). However, the negative predictive value was high (99.12%). Given that predictive values are affected by prevalence rate, interpretation at the patient level should employ the likelihood ratios applied to the prevalence rate of the population of interest (formulas and a nomogram for calculating posterior probability based on the prevalence rate or pretest probability are available at http://www.cebm.net/likelihood-ratios/).

INSERT TABLE 2

DISCUSSION

We examined the accuracy of the OSU TBI-ID as a screen for childhood history of TBI using data from a birth cohort (the CHDS) that had been evaluated on a regular basis for up to 35 years. Results suggested that a self-report of TBI with LOC was associated with a moderate to large (and often conclusive) increase in the likelihood of identifying the occurrence of a TBI event. Childhood injury with LOC is 1 of 3 primary “red flags” used to interpret OSU TBI-ID findings (the others being any history of moderate or severe TBI or any history of a period in one’s life with multiple, repeated blows to the head). Although the results here support the utility of self-reported childhood TBI with LOC, the absence of a positive finding may not indicate that none occurred. We found that earlier life TBI events (as shown on Table 1) were less likely to be recalled; this is consistent with previous literature regarding childhood memories. Research has described a period of infantile amnesia (a period early in life for which the individual has a
limited personal memory). Childhood amnesia is a robust phenomenon that usually exists for the first 2 to 4 years of life. Infantile amnesia exists whether or not the event was traumatic in nature. Recall of TBI events during this period would rely on the TBI event being sufficiently significant for it to become part of “family history.” Events that are rehearsed in the family are more likely to be recalled by the individual later in life, even though they do not represent a personal memory but rather a memory for what they have been told occurred.

There was a surprising number of “false positive” recalls for early TBI events, particularly after the age for which childhood amnesia would have less of an effect on recall. Although the medical record was used as the “gold standard” for the current purposes, it is possible that the medical record does not reflect all medically attended injuries. One reason for inconsistency between the medical record and TBI recall may relate to terminology used in the medical record. There is no consensus around terminology to be used to describe mTBI, with mild head injury, concussion, and mTBI being used interchangeably. Likewise, KOed, LOC, and knocked-out are used interchangeably to describe an LOC.

Second, in this study we were screening for early injury. TBI events during this period are usually mild, unobserved and require parental report to the medical practitioner of what the child reported or what the parents themselves observed. It has been found that parents of preschool children often do not report as many symptoms on presentation at emergency departments as do parents of school-aged children. This is likely due to very young children being unable to verbalize what has happened and therefore, if the injury was unobserved, the parent has no information. For these reasons it is possible that some TBI events that did occur were not recorded in the medical records. Alternatively, “false-positive recalls” may represent other injuries that occurred during the same period. If from the same injury event, the recall of TBI—even with LOC—is not necessarily inaccurate, other more urgent medical issues may have been the focus of medical attention, obscuring full evaluation of the TBI. It is also possible that a small number of TBI events were recorded as other injury events in the medical records, inflating the number of false positives. However, the injury events in the cohort were verified at each follow-up, and all hospital records were again checked at the 25-year follow-up. Finally, it is possible that a period of posttraumatic amnesia could be mistakenly recalled some years after the TBI event as a period of LOC.

It is pertinent to consider the limitations of the study. The cohort members were required to recall injury events at a number of times during their life. Also, their parents were encouraged to keep diaries of these events and provide recall of them. It is possible that the data produced using a cohort are overly optimistic, and this level of recall might not be found among the general population. Still, the CHDS provided a unique opportunity to evaluate the OSU TBI-ID as a screening measure as an almost complete record of all medically attended injuries, prospectively gathered, was available.

CONCLUSION

We evaluated the ability of adults to recall childhood TBI with LOC that occurred between 19 and 35 years earlier using the OSU TBI-ID. Approximately two-thirds of the TBI events with LOC were recalled. However, there were also many false recollections. This research highlights the difficulties identifying childhood TBI, particularly after extended periods following injury. However, given the general lack of understanding regarding TBI among the general public, the extensive time post injury and the inclusion
of a period in life for which no personal memory could realistically be expected (0–4 years), that two-thirds of the TBI events were recalled indicates the utility of screening for childhood TBI using the OSU TBI-ID. This conclusion was supported by the positive likelihood ratio, which indicated there was a moderate to large increase in the likelihood of identifying childhood TBI using the OSU TBI-ID.
References


### Table 1. Reporting of TBI events and whether an LOC had occurred, over 4 age bands

<table>
<thead>
<tr>
<th>Age range</th>
<th>0-3 y</th>
<th>4-7 y</th>
<th>8-11 y</th>
<th>12-15 y</th>
<th>Totals</th>
</tr>
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<tbody>
<tr>
<td>n</td>
<td>25</td>
<td>25</td>
<td>30</td>
<td>36</td>
<td>116</td>
</tr>
<tr>
<td>LOC recall</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>17&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>LOC not recalled</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>8&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Total LOC events</td>
<td>5</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>25</td>
</tr>
<tr>
<td>Incorrect LOC recall</td>
<td>5</td>
<td>15</td>
<td>17</td>
<td>19</td>
<td>56&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>No LOC correct recall</td>
<td>15</td>
<td>6</td>
<td>5</td>
<td>9</td>
<td>35&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Abbreviations: LOC, loss of consciousness; TBI, traumatic brain injury.

<sup>a</sup> True positives.

<sup>b</sup> False negatives.

<sup>c</sup> False positives.

<sup>d</sup> True negatives, plus the remainder of the available cohort.
Table 2. Sensitivity, specificity, positive, and negative predictive ratio for adult recall of traumatic brain injury with loss of consciousness

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
<th>Formula</th>
<th>95% Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>68.0%</td>
<td>$17/(17 + 8)$</td>
<td>46.5%–85.05%</td>
</tr>
<tr>
<td>Specificity</td>
<td>94.16%</td>
<td>$903/(56 + 903)$</td>
<td>92.48%–95.56%</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>23.29%</td>
<td>$17/(17 + 56)$</td>
<td>14.19%–34.65%</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>99.12%</td>
<td>$903/(8 + 903)$</td>
<td>98.28%–99.62%</td>
</tr>
<tr>
<td>Positive likelihood ratio</td>
<td>11.64%</td>
<td>$0.68/(1 - 0.9416)$</td>
<td>8.04–16.86</td>
</tr>
<tr>
<td>Negative likelihood ratio</td>
<td>0.34</td>
<td>$(1 - 0.68)/0.9416$</td>
<td>0.19–0.60</td>
</tr>
<tr>
<td>Disease prevalence</td>
<td>2.54%</td>
<td>$(17 + 8)/(17 + 8 + 56 + 903)$</td>
<td>1.65%–3.73%</td>
</tr>
</tbody>
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