

The prevalence of traumatic brain injury among young offenders in custody

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1 **The Prevalence of Traumatic Brain Injury Among Young Offenders in Custody: A**
2 **Systematic Review**

3

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27

28 **Abstract**

29 *Objectives:* To examine the prevalence of traumatic brain injury among young people in
30 custody and to compare this to estimates within the general youth population.

31 *Design:* Systematic review of research from various national contexts. Included studies were
32 assessed for the relevance of the definition of traumatic brain injury and the research
33 population, and the quality of the study design.

34 *Results:* Ten studies were identified for inclusion in the review. Four of these studies included
35 control groups. No studies examining co-morbidity of TBI and other neurodevelopmental
36 disorders among incarcerated young people were identified.

37 *Conclusion:* Reported prevalence rates of brain injury among incarcerated youth range from
38 16.5% to 72.1%, with a rate of 100% reported among a sample of young people sentenced to
39 death. This suggests considerable levels of need among incarcerated young people. Where
40 control groups or directly comparable studies within the general population exist, there is
41 strong and consistent evidence of a prevalence of traumatic brain injury among incarcerated
42 youth that is substantially greater than that in the general population. This disparity is
43 seemingly more pronounced as the severity of the injury increases.

44

45 **Keywords:**

46 Traumatic brain injury; prevalence; young offenders; crime; antisocial behaviour; custody;
47 incarceration.

48

49

50 **Introduction**

51 In recent years there have been numerous calls for improvements in the provision of
52 support to address the mental and physical health needs of prison populations¹⁻³. Addressing
53 these needs is argued to be key to individual health and well-being, preventing reoffending,
54 and reducing the costs of the criminal justice system⁴. Brain injury is a major cause of death
55 and disability in children and working age adults⁵. Nonetheless insufficient attention is given
56 to brain injury in addressing the needs of prison populations⁴.

57 A traumatic brain injury (TBI) is a disruption to the normal function of the brain
58 resulting from a direct blow to the head, penetration of the skull, or a force that causes the
59 brain to move around inside the skull⁶. The Centers for Disease Control and Prevention
60 report that the most common causes of TBI are falls (approximately 40% of reported
61 instances), road traffic accidents (20%), 'being struck by/against' an object (19%), and
62 assaults (11%)⁷. Falls are the primary causes of TBI for younger children, while traffic
63 accidents becomes the primary cause for young people aged 15-19.

64 The severity of TBI can be measured in different ways. Most commonly,
65 consideration is given to whether loss of consciousness (LOC) is experienced, and if so its
66 duration and depth, based upon the extent to which a patient is able to respond to stimuli. A
67 common classification of experiences of LOC is the Glasgow Coma Scale which provides a
68 standardised means to score its severity as 'mild', 'moderate' or 'severe'⁸. Alternatively
69 severity may be graded by the duration of 'Post-Traumatic Amnesia'; that is, the length of
70 time after an injury that a person is alert but unable to take on new information⁹.

71 Childhood TBI can result in a number of potential neurocognitive impairments and
72 developmental difficulties that subsequently impact upon aspects of functioning and
73 behaviour. These include deficits in: cognitive and socio-cognitive skills¹⁰⁻¹³; social or

74 pragmatic communication¹⁴⁻¹⁷; impulse control and regulation of aggressive responses to
75 threat^{10,18-23}; cognitive empathy²¹, and therefore the ability to respond appropriately to
76 other's emotions^{10,13,24}. Such impairments have been frequently identified as 'risk factors'
77 within criminological research²⁵⁻²⁷; that is, in population-based studies, the presence of these
78 factors have been found to increase the risk of criminality. In particular, 'neurocognitive
79 impairments' have been found to be strongly associated with 'early onset' and 'life course
80 persistent' offending trajectories, and the number of times an individual has experienced
81 LOC has been found to be significantly higher amongst persistent offenders²⁸. A failure to
82 address needs resulting from childhood TBI can lead to a range of poor social experiences
83 and outcomes known to indirectly increase vulnerability to criminal behaviour. For example,
84 TBI is associated with persistent problems in academic performance²⁹⁻³², including at the
85 point of transition to secondary school³³⁻³⁵ and susceptibility to negative peer influences^{36,37}.
86 In combination, this suggests young people may experience heightened vulnerability towards
87 antisocial and criminal behaviour as a result of impairments caused by childhood TBI; an
88 assertion that is supported by two population studies that establish a clear link between TBI
89 and subsequent offending. A birth cohort study of 12,000 subjects in Finland identified a
90 fourfold increased risk of adult offending with associated mental disorder following
91 childhood TBI³⁸. In Sweden, an analysis of hospital records across the entire population from
92 1973 to 2009 enabled comparison of outcomes for those who had experienced TBI in
93 childhood to siblings who had not experienced such an injury, and suggested an association
94 between TBI and subsequent violent crime³⁹.

95 It is equally apparent that TBI may result from certain forms of risk taking
96 behaviours, including those associated with offending⁴. This demonstrates the complexity in
97 interpreting the correlation or causal relationship between TBI and criminality. Thus brain

98 injury may result from behaviour associated with criminality, or the risk of future criminality,
99 and may instead be indicative of a pre-existing trajectory towards offending behaviour.

100 In parallel to a heightened risk of offending behaviour, childhood TBI may also
101 increase vulnerability to criminalisation through discrimination and disadvantage in
102 experiences of the criminal justice system. For example, impairments in executive
103 functioning are known to affect capacity to engage in forensic police interviewing and
104 presentation in court, potentially resulting in a young person being perceived as non-
105 compliant^{17, 40-43}. Subsequent interventions that fail to recognise and address needs may
106 result in the potential for disengagement and possible breach of a court order³⁷.

107 Articles 37 and 40 of the United Nations Convention on the Rights of the Child⁴⁴
108 establish the rights of young people within the criminal justice system to be dealt with in
109 ways that take account of their specific, individual developmental needs, providing
110 interventions that promote care, guidance and support. Given the apparent heightened
111 vulnerability to criminality and criminalisation, it is therefore imperative that criminal justice
112 systems recognise and respond to needs resulting from childhood TBI, particularly amongst
113 serious and persistent offenders. To this end, a growing number of studies have examined the
114 prevalence of TBI amongst incarcerated young people in various populations and contexts.
115 This article reports on a systematic review of this body of research in order to answer the
116 primary research question: ‘What is the prevalence of traumatic brain injury amongst
117 incarcerated young people?’ This in turn supports an answer to a secondary question: ‘Is the
118 prevalence amongst incarcerated young people greater than the rate amongst the general
119 youth population?’ Consideration is also given to sociodemographic variation in prevalence
120 rates of TBI among young people in custody, including in relation to gender and ethnicity, as
121 well as to the co-occurrence of TBI and other neurodevelopmental or mental health
122 difficulties.

123

124 **Methods**

125 The review was completed in two distinct phases. The initial phase was undertaken as
126 part of a broader examination of the prevalence of neurodevelopmental disorders amongst
127 incarcerated young people, commissioned by the Office of the Children’s Commissioner for
128 England in 2009⁴⁵. This was subsequently updated through a second phase of searches and
129 analysis undertaken in 2014.

130 Both phases followed the same search strategy. A systematic review of academic
131 journal articles was undertaken through a structured search of key bibliographical databases,
132 chosen so as to provide extensive coverage of a variety of relevant academic disciplines.
133 These included PubMed, PsychINFO and Applied Social Sciences Index and Abstracts.
134 Search terms were developed through consideration to the synonyms of a number of key
135 concepts, including ‘youth’, ‘crime’, ‘custody’ and ‘traumatic brain injury’, which were
136 combined using Boolean terms. Consideration was given to variations in terminology over
137 time and in different cultural contexts.

138 The review of academic journal articles was supplemented by a purposive search for
139 relevant evidence published by key health, criminal justice and social policy organisations.
140 However, no such sources were identified in relation to TBI. The bibliographies of included
141 sources were also searched for further relevant evidence. In addition, the initial phase of the
142 research was supported by an expert advisory group, drawn from a range of relevant
143 academic and professional disciplines and able to provide insight into emerging and
144 published research. The membership of the group is listed elsewhere⁴⁵. Specific searches
145 identified the work of key authors, as identified by the expert advisory group.

146 The senior research team was multidisciplinary, including expertise in neuroscience,
147 psychiatry, psychology, social policy and criminology. Searches were undertaken by two

148 research assistants in the first phase and one research assistant in the second phase. Each
149 research assistant had undertaken formal methods training regarding literature-based research
150 prior to their employment, and received weekly mentoring and supervision from a senior
151 member of the team throughout their involvement in the study.

152 The research protocol determined that studies were included if they provided a
153 prevalence rate for one or more neurodevelopmental disorder amongst a sample of young
154 people in custody. A broad definition of youth was applied so as to reflect the varying
155 classifications within different nation states, though all studies had to include young people
156 under 18 within their sample with a maximum upper age range of 21. The review was
157 inclusive of a wide range of definitions of particular neurodevelopmental disorders. In the
158 case of TBI, definitions used by particular studies needed, as an absolute minimum, to satisfy
159 that of the Centers for Disease Control and Prevention ⁵, which defines TBI as ‘a bump, blow
160 or jolt to the head or a penetrating head injury that disrupts the normal function of the brain.’

161 Studies were excluded if no clear definition of the nature of the neurodevelopmental
162 disorder was provided, or specific prevalence rates for young people could not be extracted
163 from the data. No specific exclusion criteria were set regarding the year of publication or the
164 geographical location of the research, though the review was necessarily restricted to
165 publications in the English language. Three studies were rejected despite a focus on
166 incarcerated young people. Two studies reported on youth justice populations that also
167 include young people within community services and do not readily distinguish between
168 these distinct populations in the data provided ^{46,47}. A further study was rejected due to the
169 conflation of TBI and epilepsy in the construction of the sample ⁴⁸.

170 All decisions regarding inclusion were made by at least two researchers, including
171 one senior researcher. It was determined that, where there was disagreement between two
172 researchers that could not be resolved, a senior researcher would further review the source

173 and determine inclusion or exclusion. Titles and abstracts were initially considered for
174 relevance. Full papers were reviewed when the abstract was deemed relevant or where
175 relevance was unclear.

176 The majority of sources identified were published in peer-reviewed academic journals
177 and therefore deemed to be of high quality. When it was unclear whether a source was peer
178 reviewed, specific frameworks for assessing research quality were utilised according to the
179 type of research study under consideration. These included the Maryland Scientific Methods
180 Scale ⁴⁹ and the Global Assessment and Evaluation of Quality framework ⁵⁰.

181 All sources selected for inclusion were read by at least two researchers, including at
182 least one senior researcher. Key information was routinely extracted and recorded in a
183 spreadsheet, including the national context, research population, sampling frame, data
184 collection method, and definition of the neurodevelopmental disorder. All reported
185 prevalence rates were recorded, including of any control groups and subsamples.

186

187 **Results**

188 The first phase of the review identified 156 sources for inclusion, of which 8 related
189 to TBI. The second phase of the review subsequently identified a further 2 sources. A total of
190 10 sources are therefore included, as listed in Table 1. No studies examining co-morbidity of
191 TBI and other neurodevelopmental disorders amongst incarcerated young people were
192 identified for inclusion. All of the studies are based on populations in the US, UK or
193 Australia. This may be a result of restriction in the review to sources written in English, or
194 may reflect a lack of emphasis on TBI in other national contexts. In all three national contexts
195 the age at which a young person is subject to the adult criminal justice system is 18, aiding
196 the direct comparison of these studies. The age ranges of samples vary, with some studies
197 focusing on a broad age range, such as 11 to 20, and others focused only on older young

198 people, such as 16 to 18 year olds. The samples for all but four studies are male only. In
199 many cases this is reported as reflective of the populations of the institutions included in the
200 study. Information on the ethnicity of study participants is less consistently provided. While
201 variation might be assumed by study population, only three studies report the ethnicity of the
202 sample and only two studies provide meaningful comparisons by ethnicity. Demographic
203 variation in reported prevalence rates of TBI are reported in the Discussion section.

204

205 **[ADD TABLE 1 AROUND HERE]**

206

207 As shown in Table 1, the reported lifetime prevalence rates of TBI amongst
208 incarcerated youth range from 16.5% to 72.1%, with the exception of a study of 14 young
209 people sentenced to death for crimes committed when aged under 18, all of whom reported
210 having experienced some form of head injury in their childhood.. There are many
211 explanations for this variability. Table 1 illustrates the varying definitions of TBI applied in
212 different studies, ranging from ‘any head injury’, including cuts, whiplash and blows to the
213 head not resulting in LOC, to trauma resulting in LOC for a minimum of 20 minutes. It is
214 clear therefore that these studies are measuring very different concepts. Nonetheless, as will
215 be examined in the discussion that follows, even where definitions appear similar, reported
216 prevalence rates still vary.

217 The variability in definition is reflected in the various measures, tools and methods
218 used to assess prevalence rates, which include: analyses of medical records; self-administered
219 surveys; semi-structured interviews; and the use of validated instruments or clinical tests.
220 Methodologies also vary in whether the respondent is the young person or parent, and
221 whether surveys are self-administered, or data is collected by a researcher or medical

222 professional. It is apparent that there is the potential for these varied approaches to lead to
223 different assessments of levels of prevalence⁵¹.

224 Comparisons are also made difficult by the variation in samples and populations on
225 which individual studies are focused. This includes variation in the age range considered,
226 which was typically dependent on the age of young people within a particular custodial
227 setting. The latter relates to a further, more significant challenge in drawing together studies
228 from various national contexts. The comparison of populations of incarcerated youth masks
229 considerable differences in the use of custodial interventions for young people in particular
230 nation states. As illustrated by the study reporting a prevalence rate of 100%, variations in the
231 seriousness of offence committed may also influence findings.

232 Studies also vary in their intent. While some studies are designed in order to establish
233 a prevalence level within a custodial population, in other studies the reported rate is a by-
234 product of a broader focus on physical and/or mental health issues or criminal justice
235 experiences. In such studies data regarding TBI may result from one or two simple questions,
236 with little depth of discussion. This variation in purpose is reflected in the sampling frames
237 utilised within the studies, ranging from convenience or purposive samples, to those that
238 deliberately include an entire custodial population.

239 Given this heterogeneity in definition, methodology and population, it is not possible
240 to calculate a robust and meaningful overall estimate of the prevalence of TBI among
241 incarcerated youth. Instead the following sections provide a discussion of the various
242 definitions used, and the range of prevalence estimates reported accordingly.

243 Where provided, prevalence rates amongst control groups drawn from non-offenders
244 in the general youth population are provided in Table 1. To support such comparison, the
245 discussion below also utilizes studies of the general youth population in which similar
246 definitions of TBI are used. These studies were purposively selected following the initial

247 review and analysis so as to provide comparable definitions. In most cases however there
248 remain slight discrepancies in definition, method of data collection and/or population. To
249 enable comparison, information on these studies is provided in Table 2.

250

251 **[ADD TABLE 2 AROUND HERE]**

252

253 Though the degree of difference varies, regardless of definition, the four studies
254 inclusive of a control group within the general youth population consistently demonstrate a
255 prevalence of TBI amongst young offenders in custodial institutions that is greater than that
256 in the general population. Similarly, where comparisons are made to studies utilising similar
257 definitions in examining prevalence in the general population, the rate amongst incarcerated
258 youth is typically higher. In part this may be explained by the higher proportion of females in
259 general population samples and the apparent lower prevalence of TBI amongst young
260 females, as discussed further below. In the following discussion, these patterns are examined
261 in relation to the common categories of definition of TBI.

262

263 **Discussion**

264 ***Any head injury***

265 In four studies a broad definition of head injury is used, incorporating a range of
266 injuries, such as cuts, and/or including blows to the head that do not result in loss of
267 consciousness. Three such studies directly compare samples of incarcerated youth to a
268 control group within school settings. Hux et al⁵⁴ asked parents a series of twenty-one
269 ‘yes/no’ questions examining awareness of head injuries experienced by their child before the
270 age of 18. The study reports that 49.7% of the incarcerated sample had experienced a

271 concussion or cut to the scalp or forehead requiring stiches, compared to 42.1% of the control
272 group.

273 Levine et al ⁵⁷ compare 53 young people in custody to an 'age-matched comparison
274 group' of 51 non-offenders from a community that is 'demographically representative of the
275 region under study'. Parental report suggests that 55% of the offender population had
276 experienced a head injury significant enough to require medical attention, compared to 24%
277 of the control group. A higher rate is reported by Davies et al ⁵². Following semi-structured
278 interviews of young people in one custodial institution in the UK, they conclude that 72.1%
279 had experienced a head injury causing them to be 'knocked out and/or dazed and confused
280 for a time'.

281 The rates amongst incarcerated youth reported in these studies appear to be greater
282 than those identified when comparable definitions are applied in studies of the general youth
283 population. For example, comparable definitions utilised in studies of high school students in
284 the US suggest a prevalence rate for any head injury of between 31% ⁶⁵ and 35% ⁶⁶. One
285 study runs counter to this trend. When surveying young offenders in custody in New South
286 Wales, Australia, Kenny and Lennings ⁵⁶ suggest that 35.1% had experienced any kind of
287 head injury, a rate in keeping with that of general population studies.

288 A different measure is employed by Forrest et al ⁵³ who consider prevalence rates in
289 the previous 12 months. In this study 'head injury' is one of a number of 'acute major
290 disorders' measured within the Child Health and Illness Profile used to assess a wide range of
291 health needs. Among incarcerated youth, 12.5% experienced a head injury in the last 12
292 months, a significantly higher rate than that of 5.8% within a control group of school
293 children. The latter is comparable to a rate of 4.7% identified by Riley et al ⁵⁷ utilising the
294 same tool and measure on a population of adolescents, aged 11 to 17, in public schools in
295 urban and rural Maryland.

296

297 *TBI resulting in LOC*

298 The disparity between prevalence rates within incarcerated and non-incarcerated
299 populations appears increasingly pronounced as the severity of the reported TBI increases.
300 This is apparent in the single study including a control group in which a range of severities of
301 TBI are measured. In the study by Hux et al ⁵⁴ the relative difference in prevalence rates
302 between the two samples increases when respondents report concussion and LOC; 11.7% of
303 the control group report some form of concussion, compared with 16.5% of the incarcerated
304 young people, while 1.5% of the control group report 'moderate' or 'severe' concussion
305 compared to 3.5% of the incarcerated young people. (A definition of the levels of severity is
306 not provided, however.)

307 The increasing disparity in relation to more severe injuries is also evident when
308 comparing reported rates in studies of incarcerated populations to studies of the general youth
309 population. Three further studies in our review consider the prevalence of TBI with any LOC
310 amongst incarcerated youth, with reported rates of 32% ⁶⁰, 41% ⁵² and 49.7% ⁵⁵. This
311 compares to rates of between 5% and 24% identified by a review of studies of self-report
312 surveys of college students in the US ⁴⁸.

313 The lower of these prevalence rates defines TBI as trauma resulting in LOC of
314 'greater than 20 minutes'. This definition is directly comparable to that of Perron and Howard
315 ⁶¹ who report that 18.3% of their sample of incarcerated youth experienced such an injury.
316 While limited to two studies, this suggests a near four times increase of such head injuries
317 amongst the incarcerated sample.

318 Elsewhere 'moderate' or 'severe' TBI is defined as a LOC of more than 30 minutes,
319 with an injury classified as 'very severe' if the LOC is greater than 60 minutes. Two studies
320 utilise this definition in examining prevalence in custodial populations; both involving self-

321 report of experience of TBI by the young person, though one in the UK⁵² and one in
322 Australia⁶⁰. The two studies report an identical prevalence rate of 8.2%.

323

324 ***Repeat incidence of TBI***

325 Two studies report on multiple experiences of TBI. Davies et al⁵² report that 45.8%
326 of their sample of incarcerated young people had experienced more than one head injury of
327 any severity, including 22.9% reporting four or more such injuries, while Moore et al⁶⁰
328 suggest that around 13% of their sample of incarcerated youth had experienced a LOC on two
329 or more occasions. While these studies did not include a control group, a self-report
330 questionnaire of high school students in the US⁶⁵ found that 12% had experienced multiple
331 head injuries of any kind, and a birth cohort study in New Zealand⁶³ with a sample size of
332 1265 reports that, by the age of 25, 9.2% had experienced more than one TBI for which a
333 diagnosis of concussion was given.

334

335 ***Sociodemographic variation in prevalence***

336 Four studies compare prevalence rates of TBI by gender amongst incarcerated youth
337 with contradictory results. Two studies report a significantly higher rate of TBI amongst
338 males than females. Perron and Howard⁶¹ report that 19.6% of males and 9.6% of females
339 had experienced a TBI resulting in LOC for at least 20 minutes, while Kenny and Lennings⁵⁶
340 suggest that 37.7% of males and only 5.3% of females have experienced one of a wide range
341 of head injury types.

342 In contrast two studies demonstrate very similar rates amongst males and females. A
343 recent study which screened young offenders in custody in New York State for TBI resulting
344 in LOC reported only one percentage point difference with a prevalence of 50% amongst
345 male respondents and 49% amongst female respondents⁵⁵. While the reported rates are

346 notably different, Moore et al⁶⁰ also suggest equivalency in prevalence with 32.1% of males
347 and 33.3% of females in their sample experienced TBI with LOC.

348 It is difficult to explain this variation between studies, even with reference to the
349 varying definitions of TBI and diverse sampling frames. While there is variation in the degree
350 of difference reported, studies of the general youth population consistently suggest a
351 significantly higher prevalence of TBI amongst males^{62,63,65}.

352 Two studies consider variation by ethnicity, though neither study reports any
353 significant difference. In a study of nine Australian detention centres⁶⁰, the rate of TBI is
354 slightly higher amongst Aboriginal young people (33.8%) than non-Aboriginal young people
355 (30.9%). Interviews with 72 young people in custody in Missouri, USA⁶¹, suggest that
356 17.8% of white young people experienced TBI with LOC for more than 20 minutes,
357 compared to 16.9% of non-white young people.

358 There is insufficient evidence upon which to draw firm conclusions, however these
359 findings would suggest that TBI might act as a risk factor for criminality independent of
360 ethnicity. Further such research examining sociodemographic characteristics is needed. In
361 particular consideration must be given to factors known to increase risk of criminality and/or
362 criminalisation that might therefore act as confounding variables in seeking to understand the
363 relationship between TBI and offending.

364

365 ***Comorbidity***

366 Several studies have identified patterns of comorbidity of TBI with other
367 neurodevelopmental disorders or mental health problems. Such associations are of two
368 distinct types. Firstly, the pre-existence of other disorders, such as Attention-Deficit
369 Hyperactivity Disorder, may heighten the risk of brain injury due to the types of behaviour or
370 activity that might more readily be engaged in⁶⁸. Secondly, there is evidence to suggest that

371 TBI might increase the risk of developing other disorders. For example, TBI can result in
372 speech and language difficulties⁶⁹ and can increase the risk of mental health problems, such
373 as depression, anxiety and suicidality^{29,70}. Young offenders reporting TBI have also been
374 found to be at greater risk of mental health problems and misuse of cannabis⁴⁷.

375 Despite the heightened risk of comorbidity, none of the studies reviewed examined
376 the co-occurrence of TBI and other conditions amongst incarcerated youth. Further research
377 is required to understand experiences of comorbidity within this vulnerable population.
378 Evidence is presented elsewhere in this special issue. In their study of young male offenders
379 in custody, Chitsabesan et al⁷¹ found that the prevalence of deliberate self-harm and suicide
380 risk factors was significantly increased in those experiencing a TBI, although rates of
381 depression and other neurodevelopmental disorders, including ADHD and speech and
382 language disorders, were not increased in this subgroup. The authors consider possible
383 mediating factors for the co-morbidity of TBI with self-harming behaviour, including the
384 presence of shared risk factors such as a history of being in care.

385

386 **Conclusion**

387 This review has identified a significant prevalence of TBI amongst young people in
388 custody in multiple national contexts. Between 49.7% and 71.2% of incarcerated young
389 people are reported to have experienced some kind of head injury, with between 16.5% and
390 49% having experienced TBI with LOC. While diverse definitions of TBI lead to a wide
391 disparity in reported rates, this suggests high levels of associated need amongst young people
392 in custody.

393 There is also strong and consistent evidence of a prevalence of TBI amongst
394 incarcerated youth that is substantially greater than that in the general population and
395 amongst offenders in community service settings. Where control groups or comparable

396 studies within the general population exist, the rates of all forms of TBI appear higher
397 amongst incarcerated youths. This disparity is seemingly more pronounced as the severity of
398 the injury increases.

399 The correlation between TBI and incarceration does not imply causation. Engaging in
400 types of behaviour related to antisocial behaviour, aggression and criminality may result in a
401 greater risk of TBI. Nonetheless, as outlined in the Introduction, the strong evidence base
402 regarding the association between TBI and subsequent deficits in a wide range of known risk
403 factors for criminality, including cognitive skills, impulse control, academic engagement, and
404 susceptibility to negative peer group influence, provides a strong theoretical framework with
405 which to understand and explain the relationship between TBI and serious and / or persistent
406 offending, and therefore the disproportionate prevalence among incarcerated youth.

407 There are a number of limitations with regard to the effectiveness of this review in
408 addressing its aims. As discussed above, there are numerous challenges in seeking to
409 combining and comparing disparate research studies with diverse definitions, samples and
410 methodologies so as to form a coherent picture of the prevalence of TBI amongst young
411 people in custodial institutions. In particular, variation in the definition of TBI utilised in
412 research, and indeed practice, inhibits clear understanding of both the prevalence of TBI and
413 its relationship to offending. Furthermore, the relatively small number of sources identified
414 demonstrates that, while greater focus is rightly being placed on this as an issue, there
415 remains a lack of robust data upon which to draw comprehensive conclusions regarding
416 levels of need or associations between serious and persistent offending and degrees of
417 severity of TBI.

418 The heterogeneity in definition of TBI and study design limits the meaningfulness of
419 combining estimates of prevalence to establish a general estimate. The review identified 10
420 studies across three countries. There are, therefore, insufficient studies from each country to

421 draw firm and meaningful comparative conclusions. Such comparison is further limited by
422 variations in policy and practice in specific states within each country, as well as by the
423 varied definitions and measures employed in each study. This precludes any meaningful
424 reflections on the relative impact or effectiveness of specific state policy and practice
425 systems. There are also some specific gaps in the available evidence. Despite the likely
426 vulnerability within this population, there appear to be particular limitations in the available
427 evidence regarding experiences of comorbidity of TBI and other developmental and mental
428 health difficulties amongst young people in custody. Similarly, few studies consider the
429 prevalence or impact of repeat experiences of childhood TBI within this population. There is
430 also insufficient consideration to sociodemographic characteristics that are commonly
431 identified within criminological research as impacting on experiences within the criminal
432 justice system, including ethnicity and socio-economic status. Given concern for experiences
433 of criminalisation and disablement amongst young people who experience childhood TBI, the
434 potential for complex and multiplicative experiences of disadvantage must be considered.

435 Notwithstanding these limitation in the evidence base, the findings presented here
436 have clear implications for youth justice systems. The high levels of need emphasise the
437 requirement for effective screening and assessment of TBI amongst offending populations so
438 as to support the development of practices and interventions better able to meet the needs of
439 young people in custody, both individually and collectively. Effective assessment provides
440 the means to understand an individual young person's history of TBI and address its potential
441 impact on aspects of behaviour and functioning. In turn, such screening and assessment can
442 provide an understanding of the collective level of need so as to inform the commissioning
443 and development of specialist services. In addition, the prevalence of TBI, and indeed other
444 neurodevelopmental disorders, amongst young people who offend suggests the need for
445 youth justice processes to be revised, given the significant proportions of young people on

446 trial or in contact with the police who may struggle to engage effectively with key aspects of
447 the legal system, including forensic interviewing and courtroom procedures.

448 An awareness of this disparity amongst populations in custody also suggests a
449 necessary focus on preventative services and earlier intervention where young people are
450 known to have been affected by TBI. This might include specialist, responsive interventions
451 during community youth justice orders. It might also inform interventions prior to any
452 significant engagement in criminal behaviour, including: the sharing of information regarding
453 TBI between health services and schools; routine follow-up support with children and their
454 families at various time points following medical attention for TBI; the provision of
455 information to parents regarding the potential short, medium and long term impacts of TBI,
456 and the availability of support services. While requiring resources, such approaches might
457 offer cost savings if preventing persistent engagement with the criminal justice system and
458 eventual incarceration for a proportion of young people experiencing childhood TBI.

459 The findings of this review also have implications regarding research in this field.
460 Comparative research between countries using standardised definitions and measures of
461 severity will support analysis regarding the influence of youth justice practices, including
462 preventative measures, on the criminality and criminalisation of young people experiencing
463 childhood TBI. This can be further supported by qualitative examination of the experiences
464 of the youth justice system and criminal justice processes of young people who have
465 experienced TBI. Consideration to and evaluation of interventions and practices better able to
466 meet the needs of young people who have experienced TBI in custodial and community
467 settings can support the development of youth justice practices better able to address the
468 needs of these vulnerable young people.

469

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Table 1. Studies reporting on the prevalence of TBI amongst young people in custody

Reference	Country	Population	Age range	Sample size	Data collection method	Definition of TBI	Prevalence rate in offending population	Prevalence rate in control group
Davies et al 2012 ⁵²	UK	Young male offenders in custody	16-18	61	Semi-structured interview carried out by researcher	Any head injury resulting in LOC or feeling 'dazed and confused'	72.1%	
						Head injury resulting in LOC of any length of time	41%	
						'Mild' TBI, with LOC of less than 10 minutes	23%	
						'Complicated mild' TBI, with LOC of 10 to 30 minutes	9.8%	
						'Moderate/severe' TBI, with LOC of 30 to 60 minutes	6.6%	
						'Very severe' TBI, with LOC of more than 60 minutes	1.6%	
Forrest et al, 2000 ⁵³	US	Young male offenders in custody	12-19	202	Self-administered questionnaire completed by young person Health screen	Taken from the Child Health and Illness Profile, Adolescent Edition in which head injury is considered as an 'acute major disorder'	12.5% in the last 12 months	5.8% in the last 12 months
Hux et al, 1998 ⁵⁴	US	Young male and female offenders in	11-20	753	Self-administered survey completed by parent	Any head injury, including cuts or whiplash, and 'blows to the head' resulting in headaches, dizziness or blurred vision, with or without LOC	49.7%	42.1%

Running head: Prevalence of TBI Among Young Offenders in Custody

		custody				Head injury resulting in concussion	16.5%	11.7%
						Head injury resulting in 'moderate' or 'severe' concussion	3.5%	1.5%
Kaba et al, 2014 ⁵⁵	US	Young male and female offenders in custody	16-18	384	Screening tool administered by professional	Head injury 'with loss of consciousness and/or posttraumatic amnesia'	49.7%	
Kenny and Lennings 2007 ⁵⁶	Australia	Young male and female offenders in custody	14-21	242	Survey administered by psychologist	Any injury 'to the scalp, skull, brain and underlying tissue and blood vessels in the head'	35.1%	
Levine et al, 1985 ⁵⁷	US	Young male offenders in custody	12-16	104	Self-administered questionnaires completed by young people and parents Medical examination Interview of parent	Head trauma significant enough to require medical attention	55%	24%
Lewis et al, 1985 ⁵⁸	US	Young male offenders in custody later convicted of murder	12-18	9	Medical records Neuropsychiatric evaluation Interview of parent	Any 'illnesses or accidents' affecting the central nervous system, including those resulting in LOC	67%	

Running head: Prevalence of TBI Among Young Offenders in Custody

Lewis et al, 1988 ⁵⁹	US	Young male offenders in custody sentenced to death	Under 18 at time of offence	14	Detailed clinical examination Interview of young person by a neurologist and a psychiatrist Medical records	Any 'illnesses or accidents' affecting the central nervous system, which in all cases includes a reported head injury	100%	
Moore et al, 2014 ⁶⁰	Australia	Young male and female offenders in custody	Not stated (mean 17)	316	Self-administered survey	Head injury 'where they became unconscious or "blacked out"'	32%	
						'Moderate/severe' TBI, with LOC of more than 60 minutes	8.2%.	
Perron and Howard, 2008 ⁶¹	US	Young male and female offenders in custody	11-20	720	Interviews administered by trained team of interviewers	Head injury causing unconsciousness for more than 20 minutes.	18.3%	

Table 2. Studies reporting on the prevalence of TBI amongst young people

Reference	Country	Population	Age range	Sample size	Data collection method	Definition of TBI	Prevalence rate
Ilie et al, 2013 ⁶²	Canada	Male and female students aged 11-20 years	11-20	8915	Self-administered questionnaire	Head injury resulting in LOC for at least 5 minutes or overnight hospitalization	20.2%
McKinley et al, 2008 ⁶³	New Zealand	Males and females at age 25	0-25	1003	Birth cohort study. Reports of TBI based on medical records from 4 months to 16 years, and self report of medical attendance from 16 to 25 years old	A blow to the head for which medical treatment was sought and a diagnosis of concussion was given	31.6%
Riley et al, 1996 ⁶⁴	US	Male and female public school students, aged 11 to 17 years	11-17	2712	Self-administered questionnaire	Taken from the Child Health and Illness Profile, Adolescent Edition in which head injury is considered as an 'acute major disorder'	4.7%
Segalowitz and Lawson, 1995 ⁶⁵	Canada	Male and female high school students	14-18	1123	Self-administered questionnaire	Any form of head injury	35%
						Head injury with concussion	14.9%
Segalowitz and Brown, 1991 ⁶⁶	Canada	Male and female high school students	14-18	616	Self-administered questionnaire	Any form of head injury	31.2%
						Head injury with concussion	15.5%