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Prevalence and Assessment of Traumatic Brain Injury in Prison Inmates: A Systematic PRISMA Review

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Abstract

The primary objectives of the present systematic PRISMA review was: (1) to explore the range of prevalence of TBI in offenders, and whether this is higher than in a control sample; (2) to determine which screening measures are available, and evaluate the evidence on these; and lastly, (3) to evaluate whether prevalence of TBI is associated with increased prevalence of other health conditions and/or offending behaviour. The present systematic PRISMA review explores the peer reviewed literature published since 2005 which has investigated TBI in incarcerated populations using five databases (CINAHL, MEDLINE, PsycARTICLES, Psychology and Behavioral Sciences Collection, PsycINFO) in addition to separate searches conducted on 'Google Scholar' using specific search criteria. Seventeen studies were identified which explored the prevalence of TBI in inmates. Only five of the seventeen studies which investigated prevalence of TBI in offender populations looked at juvenile offending. Interestingly, only seven of the 12 studies included both male and female samples (two of which did not report findings separate for males and females. In terms of the assessments used to investigate prevalence, three studies investigated the prevalence of TBI using The Ohio State University (OSU) TBI Identification method (OSU-TBI-ID). Nine studies used one or two questions in order to elicit information on whether the offender had previously experienced a TBI. Only two studies used the Traumatic Brain Injury Questionnaire (TBIQ). One study used the Brain Injury Screening Index (BISI). Lastly evidence of TBI checklist from medical record (14-items) was used in one study. In terms of the implication for further research and practice, the studies identified in this review clearly emphasise the need to account for TBI in managing care in offender populations, which may contribute to reduction in offending behaviours. Additionally, there is a need for further research investigating the clinical utility of screening tools for detecting TBI in offender populations such as The Traumatic Brain Injury Questionnaire (TBIQ), The Brain Injury Screening Index (BISI) and The Ohio State University (OSU-TBI-ID) TBI Identification method.

Key words: Traumatic brain injury; TBI; brain damage; head injury; inmates; prison; brain injury assessment;

Introduction

Traumatic brain injury (TBI), frequently the result of an external force to the head, is a leading cause of death and disability worldwide [1-3] and is a huge burden on the health care system financially [2,4,5]. An elevated prevalence rate of a history of TBI, compared to the general population, has been found in vulnerable populations including the homeless, substance abusers and prison populations [6]. A number of empirical studies have found an association between TBI and both violent and nonviolent criminal behaviours (e.g., [7,8], for review see [9]). Some studies have found history of TBI to be an independent predictor of criminal and violent behaviours, imprisonment and recidivism [10]. Neuropsychological studies indicate that the prevalence of brain dysfunction in offender populations is extremely high, with prevalence rates as high as 94% among homicide offenders [11]. In sexual homicide perpetrators, Briken and colleagues [12] found a high prevalence (30%) of heterogeneous brain abnormalities consistent with previous studies [13] but lower than the rate found by others (e.g., [14]). There is great difficulty in determining the prevalence of TBI in inmates as they are largely an 'unrecognized and vulnerable minority' [15]. Relatively little research has explored the impact of TBI on prison inmates [16].

While there have been some recent systematic reviews examining TBI in offender populations, to the authors knowledge there are no systematic reviews which have looked at both males and females and also explored both adolescents and adults. For instance, O'Sullivan and colleagues [17] conducted a systematic review looking at TBI and violent behaviour in females [17]. Another recent systematic review explored the prevalence of TBI in juvenile offenders in custody [18]. The present systematic review also explores both prevalence, assessment of TBI in offender populations.

The primary objectives of the present systematic PRISMA review was: (1) to explore the range of prevalence of TBI in offenders, and whether this is higher than in a control sample; (2) to determine which screening measures are available, and evaluate the evidence on these; and lastly, (3) to evaluate whether prevalence of TBI is associated with increased prevalence of other health conditions and/or offending behaviour.

Methods

Protocol and registration

We did not register the protocol for this review.

Eligibility Criteria

Given the relatively small number of studies in this area, it was decided that the inclusion criteria would be more inclusive than exclusive. For instance, some of the studies which were identified and included in the review were not specifically focused on examining prevalence rates but this was one aspect of their studies results (for e.g., [19,20]). Given that the prevalence was not the focus of these studies it could be argued that this may have

consequences for the interpretation of the results and inclusion in comparisons with other studies. However, while it may not be the focus of their study, this paper will nevertheless include their prevalence findings as properly carried out and to be of value

Information Sources

Internet-based bibliographic databases (Interface - EBSCOhost Research Databases searching: CINAHL, MEDLINE, PsycARTICLES, Psychology and Behavioral Sciences Collection, PsycINFO) were searched in order to access studies which investigated the prevalence and assessment of acquired brain injury in the prison population. The flowchart below outlines the process of eliminating non-relevant papers (following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, [21], see Figure 1) below. The searched included all publications published between 2005 and 2015. Duplicates were excluded prior to the retrieval of references.

Search

Searches on all five databases were originally conducted on 17th September 2015. The following search criteria were entered into the five databases: [AB (abstract) "brain injur*" OR "brain abnormalit*" OR "head injur*" OR "brain damage" OR "TBI" OR "traumatic brain injur*" OR "neurologic* abnormalit*" OR "neurologic* damage" OR "neurologic* injur*" OR "acquired brain injury" OR ABI OR "acquired head injury" OR "brain damage" OR concuss*] AND [AB (abstract) prison* OR incarcerat*].

In addition to these database searches, numerous permutations of brain injury and prison were entered into Google Scholar and thoroughly searched for articles which were not identified through the database searches, for instance, ["brain injury" AND inmates]; ["brain injury" AND inmates AND assessment AND prison]; ["brain injury" AND screening AND prison]; ["brain damage" AND screening AND prison]. For each of the searches conducted on Google Scholar, at least 25 pages were looked through for relevance (both the title and the brief caption below with highlighted relevant words and sentences within the text). As a result, at least 1,000 potentially relevant titles and brief captions were screened for relevance. Additionally, references contained in all the review papers (and many other types) identified from the database searches were also screened for possible inclusion in this review.

Abstracts for each reference were obtained and screened using the following criteria:

Inclusion criteria:

1. Human study population
2. Investigated head injury in the prison environment (for example, prevalence or assessment of brain injury in inmates).

Exclusion criteria:

1. Paper not published in English
2. Dissertations
3. Book reviews
4. Review papers (however, as mentioned above, review papers were screened, including reference section, for articles which meet the inclusion criteria for this review).

Screening:

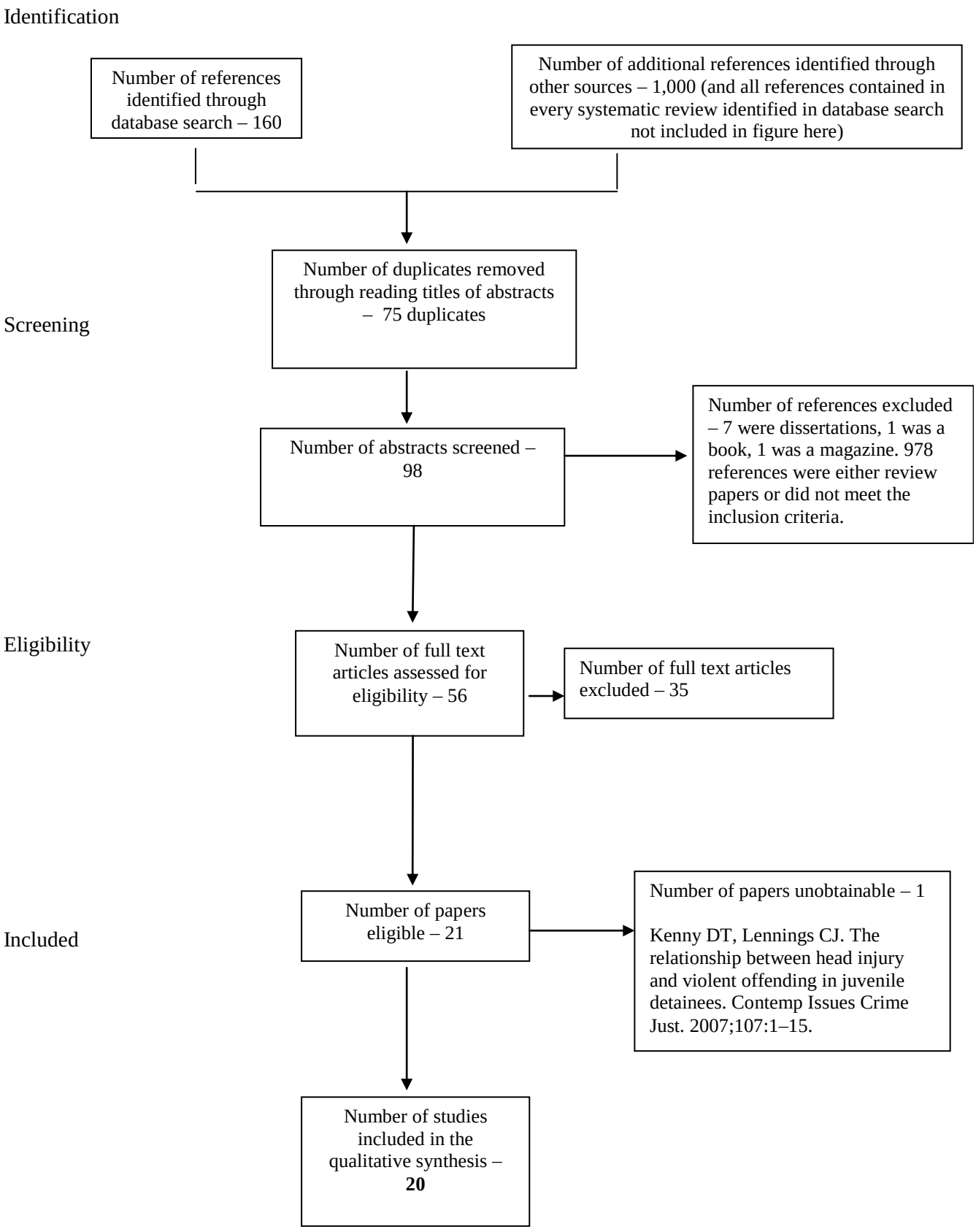
In the first stage, papers were excluded which:

- did not include an investigation of TBI (acquired brain injury, brain damage, etc)

For the next stage papers were going to be rejected which did not explore TBI in an offender population. For this study, offender population was defined as imprisonment or placement in jail, prison, a correctional facility, juvenile detention, or a detention center as a result of committing an illegal act.

Lastly, review papers and book chapters which were clearly reviews were excluded and if they were relevant, they are covered in the introduction. Full documents were obtained for the remaining records.

Figure 1. Flow of Information through Systematic Review



Results

Studies which Estimate the Diagnostic Prevalence of TBI in Inmates

Seventeen studies were identified which explored the prevalence of TBI in inmates [16,19,20, 22-35]. Only one study used a specifically designed questionnaire to investigate post-concussion symptoms. Davies and colleagues [24] used the modified version of the Rivermead Post-concussion Symptoms Questionnaire (RPSQ; [36]) to measure post-concussion symptoms in their sample of incarcerated male juvenile offenders [24]. All studies are consistent in that they all demonstrate high rates of TBI in the offender populations. See Table 1 for details of these studies and their findings of prevalence rates of TBI.

[Table 1. to be inserted here]

Only three screening instruments or methods for assessing TBI: The Traumatic Brain Injury Questionnaire (TBIQ, [38]); the Brain Injury Screening Index (BISI, [39]) and The Ohio State University (OSU) TBI Identification method [40]. One study used patients discharged from nonfederal South Carolina emergency departments or hospitals with a TBI-related ICD-9-CM Code (discussed in more detailed later). The most common way of identifying occurrence of TBI was the one or two question methods to elicit information regarding previous TBI. Each instrument and the findings are discussed later in the results.

Studies using Juvenile Samples versus Adult Samples

Five of the seventeen studies which investigated prevalence of TBI in offender populations looked at juvenile offending [24-27, 34]. We will briefly review their main findings here. Davies, Williams et al. [24] found that more than 70% reported at least one head injury at some point in their lives. Kaba, Diamond et al. [26] found that at least one TBI was reported by 259 (67.4%) of the 384 screened inmates. Lastly, Williams, Cordan et al. [34] found that TBI with or without LOC was reported by 46%. Possible TBI was reported by a further 19.1%. Two of these five studies reported relatively lower prevalances of TBI in their juvenile offender samples. Specifically, Howard, Balster et al. [25] found that head injury with extended period of unconsciousness occurred in 18.3%. Moore, Indig et al. [27] found that 32% of young people reported experiencing a TBI.

Twelve of the seventeen studies involved adults samples rather than juveniles [16, 19, 20, 22, 23, 28-33, 35]. Sixty-five per cent reported TBIs of various severities in the sample investigated by Williams, Mewse et al. [35]. Bogner and Corrigan [22] found that 78% (n = 164) of their sample had one or more TBIs. Pitman, Haddlesey et al. [19] found even higher rates of TBI in their sample with the majority of individuals (94.2%) having experienced one or more TBIs resulting in a loss of consciousness. Ferguson, Pickelsimer et al. [16] study revealed a prevalence of TBI of 65% in male inmate and 72% in female inmates.

Four studies identified in this review used the same dataset of 200 individuals [28, 31-33]. Findings reported across these four papers was that 164 (82%) out of the 200 reported having sustained a past TBI giving a total of 420 separate TBI incidents. Interestingly, this prevalence was the same as that reported by Piccolino and Solberg [29] in their sample of more than 998 offenders. However, Ray, Sapp et al. [30] found a much lower prevalence in their study with 35.7% (n = 297) of the inmates reported experiencing a TBI. In their study comprising of 100 females and 127 males, Colantonio, Kim et al. [23] identified 102 (43.4%) individuals who reported a history of TBI. The main aim of the study by Shiroma, Pickelsimer et al. [20] was to explore the association of medically attended TBI and in-prison behavioural infractions. On June 30, 2007, 1,136 (5.65%) of the 20,098 male inmates had a history of medically attended TBI that occurred between January 1996 and June 30, 2007.

Studies which Investigated Gender Differences with respect to Prevalence of TBI

Interestingly, only seven of the 12 studies included both male and female samples. First, Ferguson, Pickelsimer et al. [16] found that the prevalence of TBI among male and female inmates was 65% and 72%, respectively. So the prevalence of TBI in the female inmates was higher compared to the prevalence of TBI in the males. This is a finding which is inconsistent with the finding from Colantonio, Kim et al.[23] which found that of those who reported a history of TBI, 64 (62.7%) were males and 38 (37.3%) were females. A TBI which resulted in an alteration in consciousness was reported in 50.4% of all males and 38% of all females. Interesting, more TBIs occurred prior to the first offence for females compared to males. In female inmates, the average age of the first TBI was 21.4 years which is relatively higher than the average age of the first TBI in males which was 19.6 years. When considering this finding it is important to note that the mean age of the first crime was lower in males compared to females. Additionally, 54.3% of the female inmates reported that their TBI occurred just before or in the same year as their first criminal offence. However, in males this figure was lower, with 31.7% reporting this same timeframe of TBI occurrence. Moreover, across a wide variety of indicators (e.g., physical and sexual abuse, neglect, family alcohol abuse, family drug abuse, and witness of family violence), females who reported a TBI had significantly increased rates of abuse compared to females who had not reported any occurrence of TBI as well as the males overall. Lastly, in terms of the types of offences committed between the females and males with TBI, no significant differences were evident. The majority of the offences committed by the present sample were overall non-violent in nature. In the screening study carried out by Kaba, Diamond et al. [26] 50% of male and 49% of female adolescents were found to enter jail with a history of TBI. Interestingly, Moore, Indig et al. [27] found that young women (age range: 13-21 years) were significantly more likely to report a recent (past 6 months) TBI when compared to young men (Age range: 13-21 years). Lastly, Shiroma, Pickelsimer et al. [20] found that among female inmates, 94 (6.22%) of 1,512 females had a history of medically attended TBI. The proportion of a history of medically attended TBI while not incarcerated at the time of injury was 5.60% in males and 6.61% in females. Of injuries while not incarcerated, 21% were moderate/severe in males and 17% were moderate/severe in females. The proportion of inmates with a history of medically attended TBI while incarcerated at the time of injury was 0.46% in males and 0.08% in females. Among males incarcerated at the time of injury with a history of TBI, 28% had a history of moderate/severe medically attended TBI. Interestingly, Shiroma and colleagues [20] study showed

that in males with TBI the in-prison behavioural infraction rate was significantly increased compared with males with no TBI for all infractions, violent infractions, and non-violent infractions. Similarly, in females with TBI, the violent behavioural infraction rate was significantly higher compared to the violent behavioural infraction rates in females with no TBI. These studies above highlight the need for further study investigating gender in relation to TBI, particularly in terms of how both these factors impact on the rate of infractions, in offender populations.

Lastly, two of the seven studies which included both males and females did not report the prevalence rates of TBI for both male and females separately. Bogner & Corrigan [22] had a sample comprising of males (n = 105) and females (n = 105) but reported prevalence of TBI as an overall group. Additionally, Howard, Balster et al. [25] sample was "predominantly male" (male = 629 and female 94). Howard and colleagues [25] did not report prevalence of TBI in males and females separately. However, investigation of the prevalence of TBI in this offender sample was not the main aim of the study. The main aim of the study was focused on investigating inhalant use among incarcerated adolescents in the United States.

Summary of Findings from Studies Identified in this Review for each Instrument/Measure of Brain Injury used on Forensic Populations

One or Two Question Methods to Elicit Information Regarding Previous TBI

Both clinical practice and research frequently refer to and adopt one or two question methods to elicit information regarding previous TBI based on the standard definition of TBI [41,42]. The reliability and validity of these methods is questionable given the relatively little study or discussion that these methods have received. Researchers and clinicians have highlighted that only the most recent occurrences of TBI and the ones which are more serious will be reported adopting the one or two question method in a self-administered scale or structured telephone survey. Public health research refers to this tendency to not being able to recall past TBI as 'telescoping' [43,44]. Only 19% of the TBIs detected using structured interview were identified using the one-question self-report screening used during admission to prison [38]. Another limitation of the self-report is that it varies in the extent to which the individual has to self-diagnose whether the TBI took place [47].

Nine studies were identified in the present review which used one or two questions approach in order to elicit information on whether the offender had previously experienced a TBI [23, 24, 25, 27, 28, 31, 32, 34, 35]. Colantonio, Kim et al. [23] found that 102 (43.4%) reported a history of TBI, 125 (53.2%) did not experience a TBI, and 8 (3.4%) did not reply to the question. Of those who reported a history of TBI, 64 (62.7%) were males and 38 (37.3%) were females. 50.4% of all men and 38% of all women reported a TBI that included an alteration in consciousness. Overall, 41 individuals (44%) reported suffering one TBI in the past, 32 individuals (34%) reported two TBIs, and 20 individuals (22%) reported three or more TBIs. Davies, Williams et al. [24] study found that 70% reported at least one TBI at some point in their lives, and 41% reported experiencing a head injury with loss of consciousness. Howard, Balster et al. [25] found head injury with extended period of unconsciousness in 18.3% (n = 132) with 81.7% (n = 588) reporting no head injury with period of unconsciousness. Moore, Indig et al.

[27] study found that 32% of young people reported experiencing a TBI, and 13% reported multiple TBIs. The majority (92%) of "most serious" TBIs were defined as mild, and the most common cause was an assault (62% woman, 34% man). Based on the same study sample of 200 participants, Perkes, Schofield et al. [28], Schofield, Butler, et al. [31] and Schofield, Butler et al. [32] found that 82% endorsed a history of at least one TBI of any severity and 65% a history of TBI with a LOC. TBI with LOC was reported by 46% of the sample in the study carried out by Williams, Cordan et al. [34]. Lastly, reports consistent with TBI of various severities were given by 65% in the study conducted by Williams, Mewse et al. [35].

Traumatic Brain Injury Questionnaire (TBIQ)

The Traumatic Brain Injury Questionnaire (TBIQ; [38]) is a structured clinician-administered instrument (which takes about 15 minutes to administer but longer if multiple positive responses) and is considered to be the gold-standard method for assessing prior history of TBI [45]. The TBIQ was developed specifically for use with offender populations and collates information on frequency and severity of head injury events in addition to gathering information on the frequency and severity of a variety of cognitive and behavioural symptoms using the structured interview approach [38].

Only two studies were identified which used the TBIQ to investigate the prevalence of TBI in their offender samples [26, 29]. The first study conducted by Kaba, Diamond et al. [26] found that at least one TBI was reported by 259 (67.4%) of the 384 screened inmates. In addition, screening revealed that 50% of male and 49% of female adolescents enter jail with a history of TBI. Incidence of TBI was assessed using patient health records, and revealed an incidence of 3,107 TBI per 100,000 person-years. In the second study conducted by Piccolino and Solberg [29], they divided their offender sample into three groups. The first group had 171 (17.1%) offenders who reported no TBI history. The second group had 575 offenders (57.6%) who reported one or two events in which a TBI occurred, both of which involved either no LOC or an LOC of less than 60 minutes. The last group had 252 offenders (25.3%) who reported either at least three separate head injuries and/or at least one injury that resulted in an LOC for > 60 minutes. This study's sample of more than 998 offenders had a very high rate of TBI, with approximately 82% meeting criteria for having incurred a TBI at some point. Therefore the range reported in these two studies of any TBI was between 67.4% and 82%.

Brain Injury Screening Index (BISI)

The Brain Injury Screening Index (BISI, 19) is a six-item questionnaire which takes 5–10 minutes to administer. Previous prevalence studies were used to inform the development of the set of questions [35,46]. Question one asks how many times they had suffered a serious blow to the head that had resulted in a loss of consciousness or rendered them very confused or dazed. Question two asks what treatment they received. Question three asks

whether they had ever received a diagnosis of either epilepsy or blackouts. Question four asks whether they had any difficulties with their memory, concentration or speech. Question five asks whether they had ever received a diagnosis of attention-deficit/hyperactivity disorder (ADHD), a learning disability, any mental health problems or any type of acquired brain injury (question six).

Interestingly, only one study was identified which used the BISI to determine prevalence of TBI in their offending sample [19]. Pitman, Haddlesey et al. [19] found that the majority of individuals (94.2%) had experienced one or more TBIs resulting in LOC (40.4% – one TBI with LOC, 22.9% – two TBIs with LOC, 19.1% – three TBIs with LOC, 11.4% – four TBIs with LOC, 6.1% – five TBIs with LOC). Half of the individuals in the sample reported having experienced a moderate TBI (lost consciousness for 10 minutes to 6 hours; median category = 2) as their most severe TBI. The majority of the total number of injuries reported were mild and repeated (59.1%).

The Ohio State University (OSU) TBI Identification method

The Ohio State University (OSU-TBI-ID) TBI Identification method [40] is a structured interview developed with the aim of achieving a more reliable and valid history of TBI and provides a systematic retrospective identification method for use with populations which are considered to be at greater risk of experiencing TBIs and subsequent TBI related-behaviours and consequences. The OSU-TBI-ID elicits self- or proxy-reports of TBI which have taken place across the whole lifetime of the individual regardless of whether the injuries required or received medical attention or not. In order to reduce biases produced by the wide variety of terminology utilised (e.g., “head injury”; “concussion”; “TBI”; “loss of consciousness”; “knocked out”), the term “injury” was chosen to avoid any ambiguity and dependence on individual definitions of this term [47]. Therefore, the structured interview focuses on injuries involving the head or the neck with potentially high-velocity forces which are capable of resulting in shear injury to the brain [16].

Three studies investigated the prevalence of TBI using the OSU-TBI-ID [16, 22, 30]. Bogner and Corrigan [22] found that 78% (n = 164) of their sample had one or more TBIs. About 93% of the reported TBIs were mild (i.e., loss of consciousness (LOC) < 30 minutes) and 60% identified involved altered consciousness without LOC. About 24% of subjects had incurred more than one TBI involving LOC, and 3% incurred multiple moderate or severe TBIs. In the study carried out by Ferguson et al. [16], 65% of male releases and non-releases, and 72% and 73% of female releases and non-releases, reported at least one TBI with an alteration of consciousness. 42% of male releases and 50% of non-releases, and 50% of female releases and 33% of non-releases, reported at least one TBI with LOC. Overall, the prevalence of TBI in male inmates was 65% and 72% in female inmates. Lastly, Ray, Sapp et al. [30] found in their study that 35.7% (n = 297) of the inmates reported experiencing a TBI. Additionally, 5.9% were reported as having a possible TBI, 19.7% mild TBI, 5.8% moderate TBI, and 4.3% severe TBI.

In sum, the prevalence of TBI of any severity and frequency reported across these three studies ranged from 35.7% to 78% [16, 22, 30]. The study by Ray et al. [30] used the short form of the OSU-TBI-ID which was the study that produced this relatively low prevalence score of TBI (35.7%) compared to the other two studies [16, 22]. Interesting Ferguson et al. [16] found that the prevalence of TBI among was higher in females compared to the males (72% and 65%, respectively).

Evidence of TBI Checklist from Medical Record

One study used a TBI checklist from medical records. The checklist comprised of 14-items that formed the basis for 'accuracy' determination [33]. Schofield, Butler et al. [33] found that of the 200 participants in the study, 164 (82%) reported having sustained a past TBI giving a total of 420 separate TBI incidents". This checklist was an addition to the questions which were asked in the previous studies published by this group of researchers on the same sample [28, 31, 32].

Patients Discharged from Nonfederal South Carolina EDs or Hospitals with a TBI-related ICD-9-CM Code

Finally, one study, Shiroma, Pickelsimer et al. [20] obtained individuals who had a history of medically attended TBI. Specifically, these individuals were patients who had been discharged from non-federal South Carolina Emergency Departments or hospitals with a TBI-related The International Classification of Diseases ICD-9-CM code. To identify medically attended cases of TBI, The Centers for Disease Control and Prevention's (CDC) case definition of TBI was employed [48]. In the United States, the ICD-9-CM is the official system of assigning codes to both diagnoses and procedures related with hospital utilisation. This case definition of TBI developed by CDC corresponds to ICD-9-CM methodology using codes within the ranges 800.0 to 801.9, 803.0 to 804.9, 850.4 to 854.1, 950.1 to 950.3, 959.01, and 995.55. These codes enable the systematic identification and recording of TBIs within populations in addition to recording the severity of the TBI. Severity of the TBI was defined by the maximum Abbreviated Injury Scale (AIS; [37]) score for the head region according to the ICD-9-CM codes (ICD/AIS). Using this method, Shiroma, Pickelsimer et al. [20] the proportion of inmates with a history of moderate/severe TBI, defined as an ICD/AIS less or equal to 3, was 1.19% in males and 0.93% in females.

TBI and Identified Associations with Psychiatric Disorders and Associated Risk Factors (e. g. sexual abuse).

The studies identified in this review (including some of the ones which focused primarily on investigating prevalence of TBI in inmates) found some psychiatric associations and gender differences which merit further research attention. For instance, Ray et al. [30] found that 22.2% of the inmates with a TBI were also identified as having a psychiatric disorder compared to 9.9% of those inmates who did not report TBI. Ray and colleagues [30]

also found that inmates who reported previously having had a TBI were more likely to have had a prior incarceration compared to those inmates who did not report a previous TBI (36.2% versus 27.4%). Inmates reporting a TBI were also significantly more likely to have committed a crime against another individual compared to those inmates without a TBI [30]. Colantonio and colleagues [23] found gender differences. Specifically, female inmates with TBI were found to have experienced more early physical and sexual abuse compared to those females without a TBI (this was also the case with the male inmates with TBI compared to those without – although the difference was not as marked) [23].

Studies found in this review also indicate that individuals with TBI are at greater risk of psychiatric disorders and recidivism. Williams, Cordan and colleagues [34] found that those with self-reported TBI were also at risk of greater mental health problems and of misuse of cannabis. In their study, Schofield and colleagues [31] using a random sample of men (n = 200) recently received into the New South Wales (Australia) criminal justice system, identified an association between TBI and a history of engagement in contact sports, school expulsion, daily illicit drug use, depression and psychosis. According to the AUDIT, 44% had alcohol problems, 48% used drugs daily, 13% reported a history of self-harm or attempted suicide, 40% had scores within the distressed range on the K-10, 56% had a positive screening result for impulsive personality disorder, 50% screened positive for antisocial personality disorder, 23% screened positive for possible history of major depression and 30% screened positive for psychosis [31]. Significant levels of behavioural and psychological problems were also found in the study conducted by Pitman and colleagues [19] which investigated whether self-report of TBI in a sample of male prisoners (inmates with a TBI, n = 139; inmates without a TBI, n = 50) screened using the BISI was associated with impaired cognitive performance using standardised questionnaires and neuropsychological tests. Significantly higher scores were found in the inmates with TBI compared to the inmates without a TBI across all tests, highlighting significant behavioural and psychological problems among prisoners who may have suffered a TBI. Compared to inmates who did not report any history of TBI, inmates who had a history of more frequent and/or more severe TBIs were found to experience greater difficulties across a variety of areas including: memory difficulties; aggression; apathy; disinhibition and executive functioning. They also exhibited greater levels of anxiety and depression and achieved poorer scores in tests of neuropsychological functioning [19]. Additionally, Ray and colleagues [30] found a significant correlation between TBI and a psychiatric disorder. In the inmates who had suffered from TBI, 22.2% were found to have a psychiatric disorder compared to ‘only’ 9.9% of those with no TBI.

Lastly, one study investigated the association between medically attended TBI and in-prison behavioural infractions in a state-wide population (16,299 males and 1,270 females) [20]. Shiroma and colleagues [20] found an elevated rate of in-prison behavioural infractions in inmates with medically attended TBI. For all infractions, male inmates with TBI had an elevated rate of 32%. For all infractions, females inmates with TBI had an increased rate of 8% which was statistically non-significant. The increased rate of in-prison behavioural infractions appeared to be higher for inmates with violent infractions. Specifically, males had an increased violent infraction rate of 86% and females had an increased violent infraction rate of 144% [20].

Studies Assessing the Reliability and Validity of TBI screening assessments or the Reliability of Self-Reported TBI compared to Medical Records in Inmates

Only four studies were identified which investigate the reliability and validity of a brain injury screening instrument [38, 47, 22] or explored the level of agreement between self-report and hospital records [33]. [Studies 22 and 33 are found also in Table 1].

TBIQ

Diamond and colleagues [38] investigated the reliability and validity of the TBIQ. Findings indicated that it demonstrates good reliability and validity in offender populations [38]. However, further research needs to be conducted to further refine the TBIQ in order to increase the instrument's sensitivity [38]. Kaba and colleagues [26] highlight one area that needs further investigation. While the TBIQ has been validated among incarcerated adults, studies have yet to investigate its validity in incarcerated adolescents [26].

OSU-TBI-ID

Studies have found the OSU-TBI-ID to have both reliability and validity in detecting TBI in offender populations [22, 47]. Corrigan and Bogner [47] investigated the initial reliability and validity of the OSU-TBI-ID and found preliminary support for the reliability and predictive validity of this method, with high inter-rater reliability found with the OSU-TBI-ID. Corrigan and Bogner [47] emphasise the need for further study in this area and suggest that future studies could investigate the test-retest reliability and that the effect of substance abuse be examined in a sample with heterogeneity in terms of this factor. In the other study, Bogner and Corrigan [22] findings revealed that the test/retest reliability of the OSU-TBI-ID ranged from acceptable to high [22].

Level of Agreement between Self-Report and Hospital Records

Only one study was identified which investigated the level of agreement between self-report and hospital records in relation to information on demographic, psychological and criminographic characteristics [33]. Schofield and colleagues [33] found an association between lower level of educational attainment and more than seven TBI occurrences across the lifetime with less agreement between self-report and medical record data in terms of the specific details of the TBI. When compared with the 'gold standard' of hospital medical records, the main findings of this study conducted by Schofield and colleagues [33] indicate that self-reported TBI in prisoners is generally accurate. These findings run counter to beliefs of this population as 'dishonest' and 'unreliable'. In 70% of cases, the prisoners' reports of TBI were found to be valid based on the criteria [33].

Who Requests Psychological Services Upon Admission to Prison?

Only two studies were identified which focused on which inmates request psychological services [29, 49] (Study 29 can also be found in table 1 as one of the studies that looked at prevalence). Diamond, Magaletta, Harzke and Baxter [49] investigated a sample set of responses to the Psychological Services Inmate Questionnaire (PSIQ**)**. The sample comprised of 2,674 (2,068 males and 606 females) newly committed male and female federal offenders and found that 11% (9% for the males and 17% for the females) requested psychological services. They concluded from this that, at least for a sub-group of inmates, this is an appropriate self-referral system into correctional mental health services. Interestingly, Diamond and colleagues [49] found that male requesters were significantly more likely to report TBI compared to male non-requesters (44.6% versus 15.4%). Results also suggest that the factors which were both independent and significant predictors of service request were: male gender; receipt of mental health treatment prior to current incarceration; TBI history; present depressive symptoms; feelings of hopelessness; nervousness; difficulties with sleeping and racing thoughts [49]. Lastly, Piccolino and Solberg [29] found a significant association between TBI history and increased rates of re-offending as well as with increased use of correctional medical/psychological services (as well as increased usage of crisis interventions services). A trend was also exhibited in which inmates with a history of TBI displayed increased rates of in-prison rule infractions and reduced rates of completion of chemical dependency treatment [29].

Discussion

The primary focus of this systematic review was on studies which investigated the prevalence of brain injury in a prison sample; studies which looked at how brain injury is assessed in prison and studies which investigated the reliability and validity of assessment or screening instruments to detect TBI in inmates. During the search, the relevant papers identified highlighted two further areas of interest which were briefly covered in the results setion. Namely, TBI and identified associations with psychiatric disorders and associated risk factors (e. g. sexual abuse) and also who requests psychological services upon admission to prison.

Seventeen studies were identified which investigated the prevalence of TBI in offender populations, all of which found the prevalence of TBI in their offender populations to be high. For instance, Piccolino and Solberg [29] found a very high rate of TBI in their sample of more than 998 offenders, with approximately 82% meeting criteria for having incurred a TBI at some point in their lifetime. Of these seventeen prevalence studies, only six included some level of control sample and future studies would benefit from the inclusion of a control group (See Table 1.). Only four studies were identified which investigate the reliability and validity of a brain injury screening instrument [22, 38, 47] or explored the level of agreement between self-report and hospital records [33]. The results from the study by Corrigan and Bogner [47] emphasise the need for further study investigating the potential limits and clinical utility of retrospective, self-reported lifetime history of TBI. Only two studies were identified which focused on which inmates request psychological services [29, 49].

Some of the studies identified in this review (e.g., [19]) touch on the issue of TBI being largely unrecognised and that within the criminal justice system it is a 'hidden disability'. This issue is further exacerbated by the assessment of TBI in offender populations. For instance, while medical records are considered to be the 'gold-standard' for verifying self-reported history of TBI, this may not be true for TBI cases which are mild to moderate where medical attention was not sought [38, 45, 50, 51]. Indeed Diamond and colleagues reported that as much as 61% of TBIs amongst inmates went without medical attention or treatment [38]. Moreover, another study found that no medical attention was received in 30% of TBIs experienced by those with comorbid substance use disorders [45]. Additionally, studies have found that self-report of TBI is fairly accurate when compared to medical records (e.g., [33]). The clinical utility of TBI screening within the prison environment has been investigated (e.g., [22]) and studies identified in this review all recommend that screening for TBI could support the management and identification of inmates with a history of TBI as well as highlight the nature of the TBI-related problems.

Limitations of the relatively small number of studies conducted to date (even studies conducted much earlier – out with the search parameters of this review) include samples which are relatively small and are comprised of highly selected offenders/offenders from specific prison subgroups such as murderers or individuals on death row [14,52,53], sexual offenders [54], or individuals with substance abuse or mental health problems [10, 55]. Other have relied on convenience samples (e.g., [38,53,34] or randomly surveyed the general prison population to try to achieve a sample which is representative (e.g., [32,56]). However, relatively few studies have studied the prevalence of TBI by screening every inmate upon prison admission (e.g., [57]). Other limitations include the reliability of offenders in self-reporting TBI. Prevalence studies of self-reported TBI (particularly inmate self-reports of TBI history) produce prevalence rates which demonstrate marked inconsistency - with some finding the prevalence rate to be 25% and others finding much higher prevalence rates, even as high as 87% [32,56-58]. However, some studies have found support that such self-report accounts of TBI in inmates can be relatively reliable [33].

In sum, differing definitions of TBI applied across studies, the heterogeneity of the samples used, the relatively small sample sizes (resulting in reduced power), the varied exclusion criteria and the sparse number of studies which include control groups [33] makes generalising from the findings regarding prevalence rates of TBI across studies extremely complex [16].

Clinical Implications and Recommendations

Understanding the needs of prisoners with TBI

Only a relatively small number of studies have emphasised the importance in recognising that inmates with TBI have an increased rate of disciplinary incidents and exhibit greater difficulty with adapting to prison life and complying with prison rules and regimes (e.g., [57,59]). TBI-related behaviours may make inmates compliance

with prison regimes and rules challenging. The study by Pitman et al. [19] highlighted that specialised support should be made available to inmates who report having suffered one or more moderate to severe injuries or multiple mild TBIs (i.e., there was a loss of consciousness of up to 10 minutes on at least one occasion). Increased awareness and ability to support the management of offenders with a TBI could be established with prison staff training coupled with routine screening of TBI. For example, training the prison staff to recognise and understand that certain behaviours exhibited by an inmate with TBI are a consequence of their previous injuries as opposed to them simply being deliberately defiant [19,32,59,60,61,62]. Training prison staff on the consequences of TBI (TBI related behaviours, etc) is crucial [59,60].

Informing the Development and Delivery of Appropriate Services for Prisoners with TBI

Despite studies highlighting the significant prevalence of TBI in inmates, there has been little consideration of this in the development of policies and procedures [35]. A review, conducted in the United Kingdom and published in 2009, exploring the mental health needs of prisoners made no reference to TBI [63]. In prison populations TBI remains inadequately addressed [35].

Future Directions

The studies which investigated gender differences in prevalence of TBI and associations (such as in-prison infractions) clearly demonstrated that there are differences thus highlighting the need for further research exploring gender differences. Such knowledge and understanding will help inform the targeting of appropriate interventions and resources. Studies have argued that despite there being a smaller number of women in prison, studies indicate that there may be a higher prevalence of TBI and more long-term psychiatric and medical symptoms in female inmates compared to male inmates. Despite this, there has been significantly less research on female inmates [16]. The need for such research is emphasised by research which has found that female inmates with TBI exhibit cognitive and behavioural impairments which are different to those found in male inmates with TBI. This is evidence supporting the need for a treatment and management plan which is tailored specifically to the gender of the individual [64]. In the United Kingdom, there is currently no established valid or reliable screening tool for identifying female inmates with a TBI and associated cognitive impairment in the United Kingdom [65]. In sum, the interesting gender differences found in many of the studies discussed in this review clearly highlight the need for more studies exploring gender differences. One suggestion for further research was posited by Moore and colleagues [27] who argued that there is a need for a comprehensive psychosocial assessment (including risk of trauma and abuse) in young women reporting a history of TBI. The importance of acknowledging a history of childhood abuse, particularly how it differs by sex in offender populations has also been suggested by others (e.g., [23]).

In terms of routine screening, Sapp and Ray [66] emphasise the need for more research which replicates the use of the OSU-TBI-ID among consecutively admitted inmates in order to ascertain whether the prevalence rates detected are consistent [66].

As mentioned in the introduction, while the TBIQ [38] is considered to be the gold-standard method for assessing prior history of TBI [45], there are some limitations of the TBIQ which need to be highlighted for forensic practitioners and neuropsychologists to consider. While it evaluates the frequency and severity of current symptoms, there are only a few items which explore changes which occur to consciousness or cognition function immediately following the head trauma. There are two ways in which the inclusion of additional questions exploring the presence of changes in cognitive, psychological, or behavioural function immediately following a TBI would improve the TBIQ; 1), it would enable additional distinctions to be made between TBIs which are defined as "mild" and, 2) it may provide some insight to the effect of earlier head injury on the behaviour of the individual [26]. Lastly, the TBIQ has only been validated among incarcerated adults and it is awaiting validation with adolescents who are incarcerated [26]. This review only identified only one other study which used the TBIQ [29]. Since these two publications in 2014, to the authors knowledge, the only other place were this method has been used was in the Minnesota prison system.

The study by Ray, Sapp and Kincaid [30] identified in the present review suggested that the short version of the OSU-TBI-ID, which takes <10 min to complete, could potentially be used as part of currently used screening instruments to identify possible TBI in inmates in order to help divert them into needed treatment [30]. However, some have argued that there are problems with administering such brief screening instruments to all inmates upon admission as it may actually cause prevalence rates of TBI to be underestimated. However, as highlighted by the studies which were identified in this review, the OSU TBI Identification Method appears to be the method which has the most evidence for reliability and validity within various populations (e.g., older adult veterans and persons dually diagnosed with substance use disorders and severe mental illness). The psychometric properties of the OSU TBI-ID have been well investigated relative to other standardised methods. However, the Brain Injury Screening Questionnaire (BISQ; [67] not identified in the present review because it was not using an offender sample) is a standardised measure which also has a significant evidence-base demonstrating its reliability and validity (e.g., [68]). Regarding the OSU TBI-ID, there have been three published studies investigating the reliability of the OSU TBI-ID (two of which were identified in the present review) [22, 45, 69]. There have also been six studies which have looked at the criterion related validity of the OSU TBI-ID [22 (also included above), 45 (also included above), 70-73]. There have also been 12 studies which have looked at the construct validity of the OSU TBI-ID across a variety of different populations (two of which were identified in the present review as they were using an offender sample – 16, 30) [16, 30, 74-83].

Lastly, the OSU TBI-ID is being used in several states and is a standard element of National Institute on Disability and Rehabilitation Research (NIDRR) TBI Model Systems Programs (TBIMS) and the Veterans Affairs Polytrauma Rehabilitation Centers' TBI Model System (Website 1 - [84]).

Conclusion

The studies identified in this review support the need for screening for TBI within the criminal justice system (at any stage such as: during parole, court diversion, or while the individual is in a correctional program) [85, 86]. TBI receives no medical attention in a large number of cases and therefore access to medical records to determine history of TBI is, largely, of no 'diagnostic' use [38, 45]. In order to address this issue in the assessment of TBI, the Ohio State University developed the OSU-TBI-ID [22, 47]. Ray and colleagues [30] study highlights the clinical utility of the OSU-TBI-ID in identifying TBI in inmates and advocate that it can be easily incorporated and combined with existing screening instruments [30]. Further understanding and recognition of the prevalence of TBI in inmates and its psychiatric associations is necessary in order to inform TBI-specific prison rehabilitation programs [16].

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Conflicts of Interest

The author(s) have no conflicts of interest (financial or otherwise) to declare.

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Table 1. Studies Reporting the Prevalence of TBI in Inmates

Reference	Country	Population	Sample	Data Collection Method	Prevalence Rate in Offending Population	Prevalence Rate in Control Group
Bogner & Corrigan, 2009 [22]	United States	Inmates from 2 state correctional facilities in Ohio, 1 for women and 1 for men	Male (n = 105) & female (n = 105) (18 to 55 years)	Structured elicitation method of The Ohio State University (OSU) TBI Identification Method.	210 participants reported 529 TBIs. 78% (n = 164) had 1 or more TBIs. Among those with at least 1 TBI, the average per person was 3.23. About 93% of the reported TBIs were mild (ie, LOC < 30 mins) and 60% identified involved altered consciousness without LOC. Only 23% of subjects' worst injury did not include LOC. For 14% of the subjects, their most severe injury involved LOC > 30 mins. About 21% of subjects had just 1 TBI, 17% had 2 TBIs, 12% had 3, & 28% had 4 or more (episodes of multiple mild TBIs were counted as 1 injury). About 24% of subjects had incurred more than 1 TBI involving LOC, and 3% incurred multiple moderate or severe TBIs.	None

Reference	Country	Population	Sample	Data Collection Method	Prevalence Rate in Offending Population	Prevalence Rate in Control Group
Colantonio, Kim et al. 2014 [23]	Ontario, Canada	4 prisons—3 for male inmates and 1 for females—participated in the study.	127 males & 100 females Males with TBI (n = 64): mean age = 32.5 (SD = 9.6). Males with Non-TBI (n = 63): mean age = 36.6 (SD= 12.0). Females with TBI (n = 38): mean age = 35.1 (SD = 10.6).	2 questions: (1) Have you ever had an injury to the head, which knocked you out or at least left you dazed, confused, or disoriented? (2) How many injuries like this have you had over your lifetime? Prisoners who reported having a history of TBI received follow-up questions regarding injury event details such as time of incident, age, loss of consciousness (LOC; yes/no), LOC duration, and whether they were admitted to hospital. Persons who reported an LOC of 30 mins or less in duration were categorised as having experienced mild injury and those who reported an LOC of more than 30 minutes were categorised as having sustained a moderate or severe injury.	102 (43.4%) reported history of TBI, 125 (53.2%) did not experience a TBI, & 8 (3.4%) did not anwer question. Of those who reported a history of TBI, 64 (62.7%) were males and 38 (37.3%) were females. Overall, 41 individuals (44%) reported suffering 1 TBI in the past, 32 individuals (34%) reported 2 TBIs, and 20 individuals (22%) reported 3 or more TBIs.	None

			Females with Non-TBI (n = 62): mean age = 33.6 (SD = 10.3).			

Reference	Country	Population	Sample	Data Collection Method	Prevalence Rate in Offending Population	Prevalence Rate in Control Group
Davies, Williams et al. 2012 [24]	United Kingdom	Incarcerated male juvenile offenders	61 male juvenile offenders with an average age of 16.87 years (range, 16-18 years).	Respondents are asked whether they had ever sustained "an injury to the head that caused [them] to be knocked out and/or dazed and confused for a time." If they responded with yes, they were then asked how many times they had sustained such injuries and the duration of each period of LOC. Severity was recorded using the length of LOC of the worst injury as an index for its severity. The level of severity represented by the measures used in this study ranged from no history of TBI to very severe injury with LOC of more than 60 minutes (0 = no history; 1 = feeling dazed and confused but no LOC, minor concussion; 2 = LOC <10 minutes, mild TBI; 3 = LOC 10 to 30 minutes, complicated mild TBI; 4 =	> 70% reported at least 1 head injury at some point in their lives, and 41% reported experiencing a head injury with loss of consciousness.	None

				LOC 30 to 60 minutes, moderate/severe TBI; 5 = LOC>60 minutes, very severe TBI). Post-concussion symptoms measured using a modified version of the Rivermead Post-concussion Symptoms Questionnaire (RPSQ).		

Reference	Country	Population	Sample	Data Collection Method	Prevalence Rate in Offending Population	Prevalence Rate in Control Group
Ferguson, Pickelsimer et al. 2012 [16]	South Carolina, United States	Inmates about to be released and inmates without forthcoming releases and a random sample of prisoners by gender with lifetime or death sentences. The South Carolina Department of Corrections (SCDC)	275 men & 267 women with completed sentences and 19 men and 15 women granted parole) and a random sample of prisoners by gender with lifetime or death sentences (26 men and 34 women).	The OSU-TBI-ID, customised for this study	65% of male releases and non-releases, and 72% and 73% of female releases and non-releases, reported at least 1 TBI with an alteration of consciousness. 42% of male releases and 50% of non-releases, and 50% of female releases and 33% of non-releases, reported at least 1 TBI with LOC.	None

Howard, Balster et al. 2008 [25]	Missouri, United States	Residents of 27 Missouri Division of Youth Services facilities	Age range: 13-17 years. Averaged 15.5 (S.D. = 1.2) years of age, (n= 723) "Predominantly male". Male 629 (87.0) Female 94(13.0)	Respondents were asked to indicate whether (yes or no) they had ever experienced a head injury which caused a period of extended unconsciousness.	Head injury with extended period of unconsciousness: Yes (n = 132, 18.3%). No (n = 588, 81.7%).	None

Reference	Country	Population	Sample	Data Collection Method	Prevalence Rate in Offending Population	Prevalence Rate in Control Group
Kaba, Diamond et al. 2014 [26]	New York, United States	Newly admitted adolescents in the New York City jail system	300 males and 84 females (16-18 years).	Traumatic Brain Injury Questionnaire (TBIQ)	At least 1 TBI was reported by 259 (67.4%) of the 384 screened inmates.	The incidence of TBI in the present study is significantly higher compared to community rates (3,107 vs. 100-700 per 100,000 person-years).
Moore, Indig et al. 2014 [27]	Australia	9 juvenile detention centers.	316 young people Young women comprised 12%	Study defined TBI as a head injury where they became unconscious or “blacked-out.” Young people were asked if they ever had a head injury where they became	32% of young people reported experiencing a TBI, and 13% reported multiple TBIs.	None

			Age range: 13-21 years	unconscious or “blacked-out.”. TBI was defined as “mild” if LOC lasted for under 30 mins. “Moderate/severe” was used to define cases involving LOC for 30 mins or more.		

Reference	Country	Population	Sample	Data Collection Method	Prevalence Rate in Offending Population	Prevalence Rate in Control Group
Perkes, Schofield et al. 2011 [28]	Australia	Consecutive sample of men (n = 200) received into custody (Hunter region of New South Wales) Control group comprised men (n = 200) matched for location of usual residence.	To obtain a community comparison group of 200 individuals, this study targeted men aged between 18–56 years who resided within postcodes of usual residence of the prisoner sample. Eligibility criteria for the community controls were: male sex, aged between 18–56 years, no history	TBI was ascertained in both samples using the following question: 'How many times in your life have you had a head injury that caused you to become: dazed or confused without LOC [record frequency] or unconscious or blacked-out [record frequency]'. The prisoner questionnaire inquired about details of up to 5 individual TBI episodes, including the most recent, the first, the most severe, the second most severe and the third most severe TBI. This study also inquired about possible side-effects following the TBI and whether these had persisted: 'Following this injury (and resulting directly from it) did you experience any of the following effects?'	82% of prisoners reported at least one past TBI of any severity (i.e. with or without a LOC). 64.5% of prisoners reported at least one TBI associated with a LOC.	71.5% of community participants reported at least one past TBI of any severity (i.e. with or without a LOC). 32.2% of community participants reported at least one TBI associated with a LOC.

			of arrest (and therefore no history of incarceration) and residence in a household with a private telephone.			

Reference	Country	Population	Sample	Data Collection Method	Prevalence Rate in Offending Population	Prevalence Rate in Control Group
Piccolino and Solberg 2014 [29]	Minnesota, United States	TBI screening process that took place with 1,029 adult male, consecutive admissions to the Minnesota Department of Corrections (MNDOC) between September 2006 and January 2007.	998 adult male offenders. The average age = 32.7 years (SD = 9.8 years).	TBIQ	Offenders were divided into 3 groups. The first group had 171 (17.1%) offenders who reported no TBI history. The second group had 575 offenders (57.6%) who reported one or two events in which a TBI occurred, both of which involved either no LOC or an LOC of less than 60 minutes. The last group had 252 offenders (25.3%) who reported either at least 3 separate head injuries and/or at least one injury that resulted in an LOC for > 60 minutes. This study's sample of more than 998 offenders had a very high rate of TBI, with approximately 82% meeting criteria for having incurred a TBI at some point.	None

Reference	Country	Population	Sample	Data Collection Method	Prevalence Rate in Offending Population	Prevalence Rate in Control Group
Pitman, Haddlesey et al. 2015 [19]	United Kingdom	A closed category B local prison for males.	139 male prisoners who reported having suffered a TBI in the BISI were interviewed. Of those interviewed, 103 completed neuropsychological assessments. TBI group - Mean age: 34.36 (SD = 9.71) 50 adult male prisoners with no history of TBI	Brain Injury Screening Index (BISI) Healthcare assistant administered the Brain Injury Screening Index (BISI) to 613 consecutive prisoners during the routine first night reception screen of all new prisoners.	Majority of individuals (94.2%) had experienced 1 or more TBIs resulting in LOC (40.4% – one TBI with LOC, 22.9% – 2 TBIs with LOC, 19.1% – 3 TBIs with LOC, 11.4% – 4 TBIs with LOC, 6.1% – five TBIs with LOC). Half of the individuals in the sample reported having experienced a moderate TBI (lost consciousness for 10 minutes to 6 hours; median category = 2) as their most severe TBI. Majority of the total number of injuries reported were mild and repeated (59.1%).	No significant differences were found between the two groups for age, educational background, premorbid IQ and use of drugs and alcohol. Those with reported history of TBI were just under 18 years old at the time of their first injury, and they were significantly younger at the time of their first

			were consecutively selected and given the same interview, questionnaires and neuropsychological assessments. Control group - Mean age: 37.26 (SD = 13.29)			offence than the control group. They appeared to have acquired their first brain injury significantly earlier than they had committed their first offence.

Reference	Country	Population	Sample	Data Collection Method	Prevalence Rate in Offending Population	Prevalence Rate in Control Group
Ray, Sapp et al. 2014 [30]	United States	Male prisoners who consecutively entered incarceration into a state prison in Indiana	831 inmates in total. Inmates' ages ranged from 16 to 69 years with an average age of 32.91 years (SD = 10.25). Without TBI (N = 534), Mean age = 34.6 (SD = 10.8). With TBI (N = 297), Mean age = 34.6 (SD = 10.8).	Short form of the OSU-TBI-ID	35.7% (n = 297) of the inmates reported experiencing a TBI. 5.9% were reported as having a possible TBI, 19.7% mild TBI, 5.8% moderate TBI, and 4.3% severe TBI.	Yes

Reference	Country	Population	Sample	Data Collection Method	Prevalence Rate in Offending Population	Prevalence Rate in Control Group
Schofield, Butler, et al. 2006 [31]	New South Wales (NSW), Australia	Cross-sectional random sample of men recently received into the NSW criminal justice system	200 male study participants. Mean age = 30.6 years (SD = 8.1 years).	Participants were asked: 'How many times in your life have you had a head injury (blow to the head) that caused you to become' (1) 'dazed and confused without loss of consciousness', and (2) 'unconscious/blacked-out?' The former is referred to as 'TBI without LOC', and the latter 'TBI with LOC' in this paper. Details of up to 5 individual TBI episodes were recorded, including the most recent, first, most severe, second most severe and third most severe TBI. LOC (and duration), date of TBI, location and the cause of the TBI were also obtained.	82% had suffered a TBI either with or without a LOC; and 43% had sustained 4 or more TBIs. Among the 164 participants who reported a TBI, 79% reported at least 1 TBI with a LOC, and 19% reported TBI with no LOC. 22% of those reporting a TBI had sustained 4 or more TBIs with a LOC. 59% of those with a TBI with a LOC reported a period of unconsciousness of < 30 mins, consistent with 'mild' TBI. 78 (70%) TBI episodes were verified by hospital records. Among the 164 participants who reported a TBI, 79% reported at least 1 TBI with a LOC, and 19% reported TBI with no LOC. 22% of those reporting a TBI had sustained 4 or more TBIs with a LOC. 59% of those with a TBI with a LOC reported a period of unconsciousness of < 30 mins - 'mild' TBI.	Yes Only 3 of the 31 individuals who denied TBI (and completed the depression questionnaire) exceeded the cut-off, compared with 40 of 158 (25%) of those individuals who reported a history of TBI.

Schofield, Butler et al. 2006 [32]	NSW, Australia	Cross-sectional random sample of men recently received into the NSW criminal justice system	200 males (sample same as 33)	Participants were asked: 'How many times in your life have you had a head injury (blow to the head) that caused you to become' (1) 'dazed and confused without loss of consciousness' and (2) 'unconscious/blacked-out?' In this article, the former was referred to 'TBI with no LOC' and the latter 'TBI with a LOC'. Participants provided details of up to 5 individual TBI episodes, including the most recent, first, most severe, second most severe and third most severe TBI. LOC (and duration), date of TBI, location and cause of the TBI were obtained.	Of 200 study participants, 82% endorsed a history of at least one TBI of any severity and 65% a history of TBI with a LOC.	

Reference	Country	Population	Sample	Data Collection Method	Prevalence Rate in Offending Population	Prevalence Rate in Control Group
Schofield, Butler et al. 2011 [33]	NSW, Australia	Cross-sectional random sample of men recently received into the NSW criminal justice system	200 (sample same as 33)	Evidence of TBI checklist from medical record. 14-items that formed the basis for 'accuracy' determination: 1. Did you sustain a skull fracture? 2. Did you have a bleed to the head? 3. Were you admitted to hospital? 4. Did you have any tests or scans (such as CAT scans, x-rays) that might have confirmed any damage to the brain as a result of the head injury? 5. Did you have an operation or surgery on your head? 6. How many days were you in hospital for? 7. When did the injury occur (year)?	Of the 200 participants in the study, 164 (82%) reported having sustained a past TBI giving a total of 420 separate TBI incidents.	None

				8. What town did it occur in (e.g. Newcastle, Gosford)? 9. Where did it occur (e.g. pub, school grounds, football field)? 10. What caused you to become unconscious or dazed (e.g. fall from ladder, motor vehicle accident, assault)? 11. Which hospital (did you go to Emergency/Casualty)? 12. Which hospital (were you admitted to)? 13. Please describe (type of operation or surgery). 14. Please specify which test(s) were conducted.		

Reference	Country	Population	Sample	Data Collection Method	Prevalence Rate in Offending Population	Prevalence Rate in Control Group
Shiroma, Pickelsimer et al. 2010 [20]	United States	State secured adult correctional facilities in South Carolina for inmates with sentences of 91 days or more.	16,299 males and 1,270 females **Males** TBI (n = 1,136). Median age = 30 (SD = 9.88). Non-TBI (n = 18,962). Median age = 33 (SD = 10.92). **Females** TBI (n = 94). Median age = 34	Inmates who had previously been discharged from nonfederal South Carolina emergency departments or hospitals with a TBI-related The International Classification of Diseases ICD-9-CM code. TBI severity was defined by the maximum Abbreviated Injury Scale (AIS; [37]).	Among female inmates, 94 (6.22%) of 1,512 females had a history of medically attended TBI. Proportion of inmates with a history of moderate/severe TBI, (ICD/AIS less or equal to 3), was 1.19% in males and 0.93% in females. The proportion of a history of medically attended TBI while not incarcerated at the time of injury was 5.60% in males and 6.61% in females. Of injuries while not incarcerated, 21% were moderate/severe in males and 17% were moderate/severe in females. Proportion of inmates with history of medically attended TBI while incarcerated at the time of injury was 0.46% in males & 0.08% in females. Among males incarcerated at the time of injury with a history of TBI, 28% had a history of	Descriptive Characteristics of the SCDC Inmate Population split into males with and without TBI and females with and without TBI.

			(SD = 8.45). Non-TBI (n = 1,418) Median age = 36 (SD = 9.65).		moderate/severe medically attended TBI.	
Williams,Cordan et al. 2010 [34]	United Kingdom	Young male offenders recruited from a Young Offender Institute, a Youth Offending Team and a special needs school.	Aged 11 to 19 years (n = 186). Mean age = 16.67.	Severity of self-reported TBI measured by asking the participant: “Have you ever had a blow to the head causing you to be knocked out, and/or dazed and confused, for a period of time?” Then participants were asked to estimate the length of time they experienced a LOC, (Mild = LOC , 10 mins, Moderate = LOC < 10 mins to 6 hours, Severe = LOC > 6 hours). They were also asked: “How many times have you been knocked out and/or dazed and confused?” and also	TBI with LOC reported by 46% of the sample. LOC consistent with mild TBI was reported by 29.6%, and 16.6% reported LOC consistent with moderate to severe TBI. Possible TBI reported by a further 19.1%. Repeat injury was common – with 32% reporting more than one LOC.	None

				what the causes of their injuries were, and their age at their “worst” injury.		

Reference	Country	Population	Sample	Data Collection Method	Prevalence Rate in Offending Population	Prevalence Rate in Control Group
Williams, Mewse et al. 2010 [35]	United Kingdom	All males - custody at a local HM (Her Majesty) Prison – Category C. Participants were held in custody for a range of offences including acts of violence, drug involvement, theft or sexual offences.	453 prisoners aged between 18 and 54 years.	History of any TBI was requested with the following item: 'Have you ever had a head injury or been concussed (knocked out) for a period of time?' Respondents could check 'yes' or 'no'. If the response was 'yes' then they were asked to note 'how many times have you been knocked out?' and to 'Please give details. . . of each occasion when you had a head injury or were concussed'. For each episode they had boxes to check if it had been a road accident, fall or assault. If 'other' they could note what kind of event it was. Participants also asked to rate the LOC for each episode based on the following: less than 10 mins; 10 mins to 6 hours; 6	Of the sample, 119 (60.7%) reported a history of head injury. 64.9% of respondents reported some form of head injury event. Of the overall sample, 16% had experienced moderate-to-severe TBI and 48% had experienced Mild TBI. 60% of mild TBIs were repeated injuries.	None

				hours to 1 day and more than 1 day. Each episode was then coded as mild, moderate or severe TBI on the basis of length of reported LOC (Mild = no or less than 10 mins (LOC); moderate = 10 mins to 6 hours LOC and severe = more than 6 hours LOC).		