Concussion

Prevalence of traumatic brain injury and mental health problems among individuals within the criminal justice system

Traumatic brain injury (TBI) is associated with increased aggression and antisocial behavior. This review examined existing literature regarding TBI prevalence and associated adverse mental health among individuals within the criminal justice system. TBI prevalence varied between 12 and 82% for youths, and 23 and 87% for adults. TBI was associated with a range of negative outcomes, particularly substance abuse. However, confounding factors, including differing control groups, lack of information for timing and severity of TBI, and use of self-report measures for TBI history made it difficult to determine whether TBI was a risk factor. Future research should eliminate or counter for these confounds, to provide accurate prevalence rates of TBI and the direction of association between TBI and offending behaviors.

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Background

A long history associating traumatic brain injury (TBI) with antisocial behavior exists. Therefore, it is not surprising that there is an increasing interest in defining the impact of TBI on the criminal justice system in terms of defining potential causal factors for the likelihood of initial offending, challenging behavior during incarceration and recidivism. Early reviews on the determinants of violence identified TBI as a predictor of delinquency [1]. Research regarding children and adults on death row reported a correlation between conviction and a history of TBI, finding that 100% of adults and 57% of children had evidence of TBI in their medical histories [2,3].

Birth cohort data

Studies utilizing cohort data have found compelling evidence regarding an increase in offending behavior for those with a history of TBI that predates offending. For instance, a large population birth cohort (n = 12,058) recruited from northern Finland was prospectively followed up until the age of 31 years (n = 5589 males and n = 5345 females) [4]. In exploring associated outcomes, it was found that after controlling for confounding factors, TBI during childhood or adolescence was significantly related to later mental health disorders, with co-existing criminal behaviors evident in male cohort members (odds ratio: 4.1; 95% CI: 1.2–13.6) [4]. Likewise, data from the Christchurch Health and Development Study birth cohort (n = 1265) were used to examine outcomes of individuals between the age of 0 and 21 years with a medically verified occurrence of TBI, which required hospitalization [5]. Findings indicated that after adjusting for child and family factors, these individuals were significantly more likely to report being arrested, have drug dependence and a history of violent offences when evaluated at 25 years of age [5]. While useful in highlighting correlations between participation in criminal offending and TBI, birth cohort data do not provide

rates of TBI among individuals within the criminal justice system.

Neurobiology

It would be expected that if TBI were causally linked to offending, then supporting evidence would be available which highlights an association between damage to certain areas of the brain and antisocial behavior. Research has shown that specific areas of the cortex serve to regulate emotions [6], including the prefrontal cortex, the anterior cingulate cortex, the posterior right hemisphere and the insular cortex, and also a number of subcortical structures including the amygdala, hippocampus and thalamus (see [6] for review). Imaging studies can, therefore, identify the potential neurobiology associated with TBI that increase the likelihood offending behavior [7]. Emotion regulation is known to involve a complex interaction between cortical and subcortical systems [8]; however, patients with early onset ventral medial lesions are consistently reported as having difficulty comprehending the future consequences of risky behaviors [9]. In addition, patients with orbital frontal lesions have been found to have poor impulse control, difficulty perceiving social signals and difficulties with decision making [10,11]. And finally, damage to the anterior cingulate cortex has been found to have a role in altering perception of pain [12].

Support for neurobiology

Given the above associations between TBI and deficits in specific brain regions, it is not surprising that people with TBI have been reported to have difficulties interpreting the facial cues of others [13], and are more likely to have diminished insight into their actions or the consequence of their actions [9]. Moreover, individuals with TBI have been reported to respond more aggressively in certain situations. Increases in aggression are particularly relevant given the link between aggression and offending behaviors [14]. Baguley et al. [14] examined the prevalence of aggression among a sample of individuals with TBI (n = 228) at 6, 24 and 60 months postdischarge, and reported that at any given follow-up period, 25% of participants were classified as aggressive. Moreover, aggression was associated with depression, concurrent traumatic complaints and lower life satisfaction [14]. Similarly, aggression rates were examined in 67 individuals with a history of TBI who were recruited from an acute trauma unit and seen 3 months postinjury [15]. In this group, the prevalence of aggression was found to be over 28%, and was associated with new onset depression and poorer social functioning [15].

Despite the correlation between TBI and offending behavior, there is still considerable inconsistency regarding its prevalence among individuals within the criminal justice system. Further, where increased lifetime prevalence of TBI is identified within such populations, the direction of the association is still not clear, and may be linked to a number of pathways. For example, individuals within the criminal justice system are more likely to experience a TBI while they are incarcerated due to being involved in physical fights. In addition, children exposed to neglectful parents are more likely to be exposed to high-risk activities, thereby increasing the risk of both sustaining a TBI and also developing delinquent behavior later in life. Therefore, to more clearly elucidate these factors, this review will critically examine the current literature on lifetime prevalence of TBI in individuals presenting within the criminal justice system. Additionally, the mental health outcomes of such individuals with a history of TBI will be explored with a view to answering the following questions:

- What is the lifetime prevalence of TBI among individuals present within the criminal justice system?

- Is TBI more frequent among criminal justice populations than those within the general population?

- Is TBI among criminal justice populations associated with increased negative behavioral, psychological or social outcomes (mental health disorders, cognitive deficits among others)?

- Is there a link between TBI and criminal offending behaviors among criminal justice populations?

Methods

A systematic review of academic journal articles was undertaken. For inclusion, studies needed to be written in the English language, have results about individuals within the criminal justice system, report on adult or child prevalence rates and include a definition for TBI. A systematized literature search was conducted using the following search engines: Ovid MEDLINE (1946–September 2016), PsycINFO (1806–September 2016) and Google Scholar. A search was conducted in each database using the terms 'traumatic brain injury' or 'head injury' and 'criminal behaviors' or 'crime' or 'criminals' or 'offending behaviors' or 'antisocial behaviors'. Returned articles were screened by title, abstract or full-text accordingly. The search returned a total of 142 articles. Of these, 84 were screened by title, 20 screened by abstract and ten examined by full-text. Articles were excluded if they were found to be unrelated to the review's scope and aims, not including individuals within the criminal justice system as a sample of interest, not original research papers and dupli-

cates. Manuscripts related specifically to individuals on death row were excluded as they are not representative of the general prison population, and separate reviews have been conducted specifically for this group, for example [16]. Manual searching for additional manuscripts based on the reference lists of relevant papers was also conducted, and papers reviewed based on inclusion criteria. The final result included 29 studies fitting the above criteria to be analyzed in the review.

Results & discussion
What is the lifetime prevalence of TBI among individuals present within the criminal justice system?
Determining the lifetime prevalence of TBI among individuals within the criminal justice system is important. As outlined earlier, TBI has been associated with increased aggression and behavioral dysfunction that will likely disrupt rehabilitation efforts and negatively impact upon the maintenance of social support networks [17]. Youth and adults within the criminal justice system need to be considered separately as biologically, youth are still in the process of developmental change [18,19]. Because of psychosocial immaturity, youth with TBI are likely to have increased difficulties compared with adults in the criminal justice system with the same history. Further, interventions designed to reduce recidivism will have a different focus for youths versus adults [20].

As is evident in Table 1 (literature search results regarding adults within the criminal justice system) and Table 2 (literature search results for adolescents and youths within the criminal justice system), prevalence rates of TBI vary widely, with estimates between 12 and 82% for the adolescent and youth populations, and 23 and 87% for adults. The variability in prevalence rates that is reported across studies is likely due to a number of factors, including large variation in the age of different samples, differences among sample inclusion criteria and diversity of countries from which the rates are extracted, which included the UK, the USA, Australia and New Zealand.

Arguably, the most confounding factor for the accurate identification of TBI prevalence rates among individuals within the criminal justice system is the different terminologies and definitions used for TBI. Inclusion criteria have varied greatly, with some studies requiring a self-report of concussive symptoms (headaches, dizziness, among others), while others include those with a period of loss of consciousness (LOC). For example, as shown in Table 2, one study required a self-reported LOC of >20 min to determine TBI [43], while another, as summarized in Table 1, required a self-report of head injury or concussive symptoms [26].

Further, while most studies carefully elicit information about the mode of injury which could have resulted in TBI (i.e., falls, vehicle collisions, fights), the terminology used to assess the prevalence of TBI varied, with researchers using terms 'head injury', 'concussion' and 'TBI' interchangeably. However, lay persons generally have very little knowledge about what constitutes a TBI and may or may not report an injury depending which term is used [50]. Researchers have previously pointed out the importance of careful questioning regarding the incidence of TBI to elicit recall [31]. For example, a single question may be misinterpreted by the informant (self or significant other), depending on whether there is sufficient cueing to enhance recall. It has previously been pointed out that one or two items on a self-report is likely to underestimate lifetime exposure of TBI events and that questioning by a trained interviewer is likely to increase recall [51]. Further, careful consideration should be given to females where mode has been intimate partner abuse and not recognized as TBI [52].

To accurately determine lifetime prevalence of TBI among populations of individuals within the criminal justice system, research requires consistency among samples and the measures utilized which serve to elicit information about a TBI event. Further, the measures must ensure that the respondents are aware of different terminology used to denote injury including slang (e.g., 'getting the bash'), as well as typical mode of injury that results in TBI, in order to cue and elicit accurate recall.

Gender issues
There is very little information regarding females in criminal justice populations from which the prevalence of TBI or outcomes associated with a history of a TBI event can be evaluated. To date, the vast majority of studies examining criminal justice populations have focused on males. Where prevalence of females with TBI is examined, the trend found in the general population is mirrored in criminal justice populations, with men outnumbering women. For example, Colantonio et al. [35] surveyed 235 males and females within the criminal justice system, and found a self-reported prevalence of 50.4% for males and 38% for females. Alternatively, in an evaluation of the lifetime prevalence of self-reported TBI for 991 males and 88 females within the criminal justice system, slightly lower rates were identified, with 32% for males and 22.7% for females [37]. Unfortunately, females were not included in analyses that examined timing of first injury for TBI compared with that of non-TBI. Again finding different results, one large study reported a reverse trend with slightly higher rates for females (72% compared with

Study	Participants	TBI definition	TBI predating offending	Control	Outcome	Ref.
1.	19–27 years n = 129 Mean 21 years 100% males	SR – HI	NR	First 41 detainees interviewed without TBI	Prevalence of TBI = 31.7% ↑ Rule violations for individuals with TBI	[21]
2.	20–69 years n = 118 Mean 31 years 100% males	SR – HI	NR	General population	Prevalence of TBI = 86.4% ↑ Substance use in prison sample compared with general male population (40%) ↓ Alcohol use for prison sample compared with general male population (89 vs 96%)	[22]
3.	n = 50 Mean 31 years 100% males	SR – HI with LOC >30 min or TBI with problems	NR	NR	Performed more poorly than age-based norms for all neuropsychological tasks	[23]
4.	n = 1000 Mean 28.5 years 100% males	SR – head trauma with or without LOC	NR	Prisoners without HI	Prevalence of TBI = 24.9% 76% of TBI resulted in LOC; 20% of those with TBI participants reported atleast one residual symptom	[24]
5.	n = 49 Mean 35 years 36 charged with violent offences 100% male	SR – blow to head/head injury	NR	Nonviolent detainees	Prevalence of TBI = 77.8% (violent) vs 46.2% (nonviolent) Severity of TBI linked to violent offending TBI plus learning disability/school behavioral problems increases risk of delinquent behavior	[25]
6.	n = 69 18–59+ years Cognitive outcomes assessed in 50 (25 TBI) 100% males	SR – HI, LOC and/or concussive symptoms	NR	First 25 with TBI over last 12 months vs 25 without TBI in last 12 months (cognitive outcomes)	Prevalence of TBI = 87% lifetime, 36.2% in prior year ↑ Anger/aggression in TBI group in 12 months prior ↑ Cognitive deficits in TBI group in 12 months prior ↑ Higher level of psychiatric disorders in TBI group in 12 months prior	[26]
7.	n = 113 18–52 years Mean 33.2 years 100% females (27 with violent offences)	SR supported by visible damage to skull or face + medical records	Age at first conviction	86 nonviolent detainees	Prevalence = 42% with ≥1 TBI events with LOC 95% of entire sample = neurological abnormalities predating current crime Cortisol correlated with higher number of TBI with LOC Hx of TBI significantly higher in those with violent offences	[27]
8.	n = 200 18–40+ years Mean 30.6 years 100% males	SR – HI with/without LOC, medical validated (70%)	NR	Detainees without TBI	Prevalence of TBI = 82% Hx TBI = 2.5× more likely to have drug abuse problem Hx TBI with LOC = ↑ depression	[28]

↓: Decreased rate; ↑: Increased rate; HI: Head injury; Hx: History; LOC: Loss of consciousness; NR: Not recorded; SR: Self-report; TBI: Traumatic brain injury.

Study	Participants	TBI definition	TBI predating offending	Control	Outcome	Ref.
9.	n = 100 18–40+ years Mean 30.6 years 100% males	SR – HI with/ without LOC, medical validated (70%)	NR	Not relevant characteristics of TBI reported	Prevalence of TBI = 82% LOC for 79% of TBI cases 43% = ≥4 TBIs Two-thirds of TBI with LOC = reported requiring medical care 52% of TBI = reported ongoing problems mean of 7 years postinjury	[29]
10.	n = 394 Mean 37.3 years n = 248 males (63%)	SR + file review, evidence of LOC	Medical evidence for some	Detainees without Hx of TBI	Prevalence of TBI = 22.6% (92% male) SR (73% or documented in health records) LOC from 1 day to 36 weeks TBI Hx associated with ↑ alcohol/ substance abuse	[30]
11.	n = 256 18+ years n = 107 males (41%)	SR – 15 questions related to lifetime Hx of head injury	NR	Not applicable	Prevalence of TBI = 88% Mean number TBI = 3 per person 50% of TBI resulted in LOC	[31]
12.	n = 210 18–55 years Mean 32.7 years n = 105 males (50%)	SR – TBI with altered consciousness	NR	None	Prevalence = 78% with TBI Mean number TBI = 2.5 per person 45% with TBI had no medical attention	[32]
13.	n = 200 18–56 years Mean 30.6 years 100% males	SR – HI with / without LOC	NR	Community sample n = 200 men, no Hx of arrest	Prevalence of TBI = 82% in criminal justice system vs 72% community sample LOC and multiple TBI = more common in criminal justice group TBI associated with ↑ impulsivity	[33]
14.	n = 636 18+ years Mean 35.5 years n = 316 females (49%), 320 males (51%)	SR – TBI	Age of first TBI collected	None	Prevalence of TBI = 67.8% (65% males vs 72% females) TBI with LOC varied from 42.2 to 33.3% depending on group (male/ female; imminent release/life) Most common persistent symptoms – headaches	[34]
15.	n = 235 18–45+ years Mean 34.4 years n = 131 males (56%), 104 females (44%)	SR – LOC or concussion	NR	Detainees without TBI	Prevalence of TBI = 43.4–50.4% of all men, 38% of all women. Females more likely to have TBI prior to criminal activity than males 7% of males and 8% of females reported no substance abuse Higher rates of abuse among females with TBI No difference between groups for offences, majority nonviolent	[35]

↓: Decreased rate; ↑: Increased rate; HI: Head injury; Hx: History; LOC: Loss of consciousness; NR: Not recorded; SR: Self-report; TBI: Traumatic brain injury.

Study	Participants	TBI definition	TBI predating offending	Control	Outcome	Ref.
			Table 1. Prevalence of traumatic brain injury, among adults within the criminal justice system (cont.).			
16.	n = 831 16–69 years Mean 32.9 years 100% males	SR – TBI	Examined association between prior TBI and current offending	Not applicable	Prevalence of TBI = 35.7% Individuals with Hx of TBI and incidence of incarceration significant ↑ Psychiatric problems associated with Hx of TBI	[36]
17.	n = 1079 18+ years Mean 30 years n = 991 males (92%), 88 females (8%)	SR – HI resulted in LOC/or concussion	NR	Detainees without TBI	Prevalence of TBI = 32% for males, 22.7% for females 14% of males sustained first TBI in prison Time in custody significantly longer for those with TBI Perceived health significantly worse for TBI TBI Hx ↑ of psychiatric disorder TBI group ↑ regular cannabis use	[37]
18.	n = 636 Mean 35.5 years 18+ years n = 316 females (49%), 320 males (51%)	SR – TBI	Age of TBI occurrence	Detainees without TBI	Prevalence of TBI = 68% (71.5% for females, 64.1% for males) 51.1% reported first drug use prior to TBI Hx TBI reported significantly younger age of drug use initiation TBI group ↑ drug use severity	[38]
19.	n = 38 18+ years Mean 33 years 100% females	SR – TBI	Age of TBI occurrence		Prevalence of TBI = 94.7% Younger age at injury associated with ↑ mental health problems	[39]

↓: Decreased rate; ↑: Increased rate; HI: Head injury; Hx: History; LOC: Loss of consciousness; NR: Not recorded; SR: Self-report; TBI: Traumatic brain injury.

males 65%) [34]. When exploring a female-only sample, consisting of 38 women within the criminal justice system, as many as 94% of participants self-reported a history of TBI [39].

Is TBI more frequent among criminal justice populations than those within the general population?

Determining whether prevalence of TBI is higher among individuals in the criminal justice system, when compared with individuals in the general population is difficult. TBI is very common within the general population, with prevalence rates varying depending on whether they are based on hospital discharge or population-based samples, general self-report or specific subsamples of nonincarcerated individuals [53,54]. Table 3 provides a sample of studies examining prevalence of TBI in the noncriminal justice system population. Prevalence rates differ depending on whether they are based on a medical diagnosis (5.7–31.0%), self-report (31.0–44.0%) or self-reported within specific vulnerable populations (29.5–80.0%). Prevalence

of verified TBI, using prospectively collected data from a birth cohort, has reported a lifetime prevalence of approximately 31% by the age of 25 years (38% among males vs 24% for females) [55]. It has also been noted that children aged 0–5 years, and males aged between 15 and 25 years, are at an increased risk for experiencing a TBI event [55,56]. Further predictors for individuals more at risk of having a TBI include male gender, high maternal punitiveness, and greater number of adverse life events [57], drug use, a history of mental illness and homelessness (see [58] for review).

Similar prevalence rates are evident for criminal justice versus noncriminal justice samples depending on the subpopulation from which they were drawn. Between 12 and 82% of youths within the criminal justice system self-reported TBI compared with between 31 and 50% of youth in the general population. In the nal justice system who also have high rates of drug use are similar.

The fact that research has found similar prevalence rates – depending on the subsample studied – strongly suggests that rather than there being a direct

Table 2. Prevalence for traumatic brain injury, among adolescent and youth within the criminal justice system.								
Study	n	Age	Gender	TBI definition	TBI prior to offending	Control	Outcome	Ref.
1.	316	11–20 years Mean: 15.4 years	67% males	Parental report HI	NR	School youths n = 437, 48% males	Prevalence of TBI = 49.68% within criminal justice system, 42.1% school youths	[40]
2.	202	12–19 years	100% males	SR – HI	NR	School youth n = 379, 100% males	Prevalence of TBI = ↑ among youths in criminal justice system (12.5 vs 5.8%)	[41]
3.	242	14–21 years Mean: 17.2 years	223 males (92%),19 females (8%)	SR – TBI blacked out or LOC	NR	Detainees without TBI	Prevalence of TBI = 35.1% (n = 1 female with TBI) TBI group = 30.6% reported ≥1 TBI TBI group = ↑ harmful alcohol use 50% of those with TBI reported cognitive or behavioral problems ↑ severe violent offending for those with Hx TBI	[42]
4.	723	11–20 years Mean: 15.5 years	87% males	SR – HI resulting in LOC >20 min	NR	Detainees without TBI	Prevalence of TBI = 18% TBI group = more likely to have Hx of substance use TBI group = ↑ mental illness (64 vs 49% controls) TBI group = younger mean age when first convicted Hx TBI = increase risk of victimization (89 vs 74% controls)	[43]
5.	186	11–19 years Mean: 16.67 years	100% males	SR – TBI with LOC	NR	Detainees without TBI	Prevalence of TBI = 46% TBI group = average ≥2 convictions Higher violence linked to >3 TBI TBI Hx = ↑ of mental health problems TBI Hx = ↑ risk of cannabis misuse	[44]
6.	186	11–19 years Mean: 16.67 years	100% males	SR	NR	Detainees without TBI	Prevalence of TBI = 46% with LOC, repeat TBI = 32% TBI Hx = ↑ rate of violence in offences TBI group = ↑ mental health problems and cannabis use	[45]
7.	61	16–18 years Mean: 16.87 years	100% males	SR – HI with LOC/or concussion	NR	Detainees without TBI	Prevalence of TBI = 71% Increase in PCS with increase in TBI severity Severity of TBI related to alcohol use	[46]

↑: Increased rate; HI: Head injury; BI: Brain injury; Hx: History; LOC: Loss of consciousness; PCS: Post-concussive symptom; SR: Self-report; TBI: Traumatic brain injury.

Study	n	Age	Gender	TBI definition	TBI prior to offending	Control	Outcome	Ref.
8.	316	13–21 years	277 males (88%), 39 females (12%)	SR – HI with LOC	NR	Not applicable	Prevalence of ≥1 TBI = 32% Majority of TBI result of assault 31% reported ongoing neurological effects of TBI TBI associated with ↑ psychological distress, Hx of being bullied, alcohol, drug use TBI group = significantly more likely to be reincarcerated during 18 months follow-up	[47]
9.	384 n = 191 TBI, 68 multiple minor injuries	16–18 years Mean: 17 years	300 males (78%), 84 females (22%)	SR – HI with or without LOC	NR	No injury/ one minimal injury with no altered state (n = 125)	Prevalence of TBI = 67% (50% for males, 49% for females) More severe TBI = ↑ use of in-jail mental health services Females more likely to use mental health services Males in TBI group = more likely to reoffend than females	[48]
10.	93	15–18 years Mean: 16.5 years	100% males	SR – BI with LOC/or concussion	NR	Detainees without TBI	Prevalence of TBI = 82% 55% reported multiple TBI 44% TBI reported ongoing concussive symptoms	[49]
11.	69	13–18 years Mean: 16 years	100% females	SR – HI with LOC/or concussion	NR	Detainees without TBI	Prevalence of TBI = 23%	[37]

Table 2. Prevalence for traumatic brain injury, among adolescent and youth within the criminal justice system (cont.).

↑: Increased rate; HI: Head injury; BI: Brain injury; Hx: History; LOC: Loss of consciousness; PCS: Post-concussive symptom; SR: Self-report; TBI: Traumatic brain injury.

link between TBI and increased risk of involvement in criminal justice system, other social and economic factors may play a role in the association.

The almost exclusive reliance on self-report measures for identifying history of TBI within the criminal justice system populations, compared with that of general population estimates (which are usually derived from medically verified reports of TBI) is likely to lead to misleading results. The prevalence of TBI varies depending on the sample and method used to collect information. More specifically, the question of whether self-report is an accurate method of ascertaining lifetime prevalence among any population has not been well researched. As such, the nature of self-report measures in identifying TBI history will be considered here.

Accuracy of self-report

Accuracy of self-report for history of TBI has been examined for 112 individuals who provided access to medical records to confirm or deny a TBI diagnosis [67]. In cross-checking self-reported TBI events with medical records, moderate to strong evidence (true positives) was found for 66% of cases, and weak or no evidence (false positives) was found for 44% of cases. No information was available for TBI events that were not recalled (false negatives), or where no TBI event took place (true negatives) [67]. In a recent study using birth cohort data, individuals aged 25 years were asked to recall verified TBI events that occurred between the ages 0 and 10 years [68]. Researchers identified that those with a TBI that occurred between the ages of 0 and 5 years recalled <10% of injuries accurately, and for individuals with a TBI event during the ages 6–10 years, 31% were correctly recalled [68]. These results suggest that memory for TBI tends to improve with age and with severity of injury. However, in this study only 50% of injuries that involved a LOC were recalled. In a further study utilizing the same sample

group, but restricting recall to TBI events that required hospitalization, self-report remained inaccurate; that is, just over 50% of the verified hospitalized TBI events were correctly recalled in the cohort [69]. Injury events involving LOC were associated with a higher level of recall accuracy, with 68% of hospitalized TBI events that resulted in LOC being recalled. However, a remaining 32% of hospitalized events with LOC were not recalled, and a large number of TBI events were incorrectly recalled (i.e., there was no evidence that the injuries had occurred) [69]. Further, individuals with multiple injuries often did not recall all of the injury events [69]. Even when considering more severe TBI events that occurred within 5 years prior to the assessment, not all occurrences were always reported, potentially due to being overshadowed by other accompanying injuries such as fractures or internal injuries to other organs. Of particular concern was the inaccuracy for early TBI, which was significantly less likely to be elicited via self-report in adulthood [69].

These studies demonstrate the inaccuracy of self-report which is likely a result of a number of issues including being too young at the time of injury to have a memory for the event, forgetting due to time

Table 3. Prevalence for traumatic brain injury in noncriminal justice populations for medically confirmed and self-report in general and subpopulations.			
Participants	**TBI definition**	**Prevalence of TBI**	**Ref.**
Medically identified TBI			
n = 7485 Males and females Age = 20–64 years	Self-report of serious head injury with LoC	Prevalence = 5.7% involving LOC ≥15 min	[52]
n = 1265 Males and females Age = 0–25 years	Medical diagnosis of TBI	Prevalence = 32%	[55]
n = 7170 Males and females Age = 18–50+ years	Audit of medical records	Prevalence = 23.9% mTBI	[59]
Self-reported TBI			
n = 616 Males and females Age: 18 years	Self-report lifetime history of TBI	Prevalence = 31%	[60]
n = 137 Males and females Age = 12–19 years	Self-report lifetime history of TBI	Prevalence = 33–50%	[61]
n = 135 Males and females Age = 14–15 years	Self-report history of TBI over last 3 years	3 years prevalence = 44%	[62]
n = 2701 Males and females Age: >18 years	Self-report lifetime history of TBI	Prevalence = 42.4%	[63]
Self-report TBI for specific nonincarcerated sample			
n = 173 Males and females Individuals with HIV	Self-report lifetime history of TBI	Prevalence = 74%	[64]
n = 51 Males and females Co-occurring mental illness and substance use	Self-report lifetime history of TBI	Prevalence = 72%	[51]
n = 95 Males and females Cocaine-dependent volunteers	Self-report lifetime history of TBI	Prevalence = 29.5%	[65]
n = 295 Males and females Co-occurring mental illness and substance use	Self-report lifetime history of TBI	Prevalence = 80%	[66]
LoC: Loss of consciousness; mTBI: Mild traumatic brain injury; TBI: Traumatic brain injury.			

lapse since TBI, or other medical issues being more overt at the time of the injury and taking precedence (i.e., broken bones or internal injuries). As pointed out by Merbitz *et al.* [21], an additional problem associated with self-report for populations based within the criminal justice system is the possibility that the self-report of TBI may be given in order to receive a certain advantage (e.g., differential cell assignments or therapy opportunities), thereby increasing the rates of false positives.

Given the difficulties with self-report, other methods need to be considered to ensure accuracy in obtaining incidence and prevalence rates. These could include confirming self-report accident data with that of medical information or seeking collateral information from parents, or significant others.

Criteria used to define TBI

As outlined earlier, comparisons between self-reported TBI among individuals within the criminal justice system and the general population, are further complicated by the varying inclusion criteria used to determine whether a TBI has taken place. Within the general population, standard criteria are used to define mild/moderate and severe TBI. The presence of an LOC is not generally used as a lower inclusion criterion for mild TBI (see [70] for review of generally accepted criteria). However, five of the studies reviewed here used LOC as an inclusion criterion (see Tables 1 & 2). The use of self-report and inclusion criteria that are different from those employed within the general population severely limit any attempt to compare prevalence rates between community and criminal justice system samples. Therefore, it is nearly impossible to determine whether individuals with TBI are more likely than the general population to engage in offending behavior unless the reports are compared with similar subsamples in the general population who have not been involved with the criminal justice system (as shown on Table 3).

Is TBI among criminal justice populations associated with increased behavioral, psychological or social negative outcomes (mental health disorders, cognitive deficits, among others)?

In many of the studies reviewed (Tables 1 & 2), a self-reported history of TBI was found to be associated with a variety of negative outcomes, including deficits in cognition [23,43], higher rates of mental health problems [28,43], and increased rates of aggression [26,42]. Increases in violent offending were also linked to a history of TBI [21,27]. The most commonly reported negative outcome, however, was rates of drug abuse, which

were recorded to be higher for those with TBI at any age compared with the control group [28,30,35,42–44,46]. The literature reviewed in Tables 1 & 2 suggests that individuals in the criminal justice system with a self-reported history of TBI do have a number of deficits and negative outcomes. However, some consideration needs to be given to the control groups used to quantify this increased risk.

Control groups

Most studies examining outcomes reviewed an association between TBI versus a control group (either a community group or individuals in the criminal justice system without TBI), without consideration about the appropriateness of the comparison/control group being utilized. For example, a number of the studies reviewed here (see Tables 1 & 2) directly examined the association between a self-reported history of TBI among individuals who have committed violent versus nonviolent crimes [25,27]. However, violent offending is more often associated with physical altercation, which in itself increases the risk of a TBI event. This being the case, dividing groups into those who have committed a violent crime as compared with those who have not, and then eliciting information about a TBI history, will distort the outcome. This is particularly true considering that most of the research to date does not consider the timing of the TBI event (i.e., did it occur prior to the offense, during the offense, or when already within the criminal justice system?).

Further, there is a lack of consideration to different severity levels of TBI. It would be expected that a degree of dose–response would be evident, such that those with more severe injury would be likely to demonstrate a greater number of problems. However, a number of the studies reviewed reported that a history of TBI, regardless of age of injury, or injury severity – including concussion, was reported as being associated with negative outcomes. One of the few studies in which the issue of injury severity was evaluated was conducted by Kaba *et al.* [48], whereby outcomes were compared between 300 males who have been in the criminal justice system for some time, and 84 males new to the system, separating TBI according to injury severity. In doing this, the study reported that those with more severe injury used significantly more in-jail mental health services than those with injury or minimal injury without altered state of consciousness [48].

The importance of appropriate control groups is highlighted by the prevalence of self-reported TBI within nonincarcerated samples who have co-occurring mental health problems as shown on Table 3. The

presence of drug and alcohol abuse problems is associated with an increased prevalence of self-reported TBI among nonincarcerated samples and at a similar rate to those within the criminal justice system. The general lack of control for preinjury functioning in the existing literature, or in some cases the lack of an appropriate control group, limits the degree to which the relationship between these outcomes and TBI can be evaluated.

Is there a link between TBI & criminal offending behaviors among criminal justice populations?

Perhaps more problematic in terms of examining whether a history of TBI increases negative outcomes for criminal justice populations is that very few studies have explored whether the self-reported TBI predated first contact with the legal system. Notable exceptions to this were a study in which the authors examined age at first injury, and reported an association between TBI and earlier initiation of drug use [38]. To examine the association between negative outcomes, offending behaviors and TBI, research protocol will require some attention to the timing of the TBI event. If the TBI event occurs after first contact with the legal or mental health system, the association with TBI is not clear. In many of the studies reviewed, an attempt to overcome this confound is made by using a control group which consists of individuals within the criminal justice system who do not have a self-reported history of TBI. However, this type of control does not overcome the possibility that the increased mental health issues and drug and alcohol misuse, also increase the likelihood of a TBI event occurring.

Outcomes for female offenders

Female and males within the criminal justice system unsurprisingly have different characteristics [71]. Therefore, it is essential that the outcomes for such female samples with TBI be considered separately from those of males. However, generally where females have been included in samples, results are not examined separately, obscuring the outcomes for female with TBI in the criminal justice system. Exceptions to this include the study of [27], where outcomes for females were exclusively examined (individuals charged for violent vs nonviolent offences), and reported that 95% of all individuals had neurological abnormalities predating their offence. Further, a history of TBI was also found to be higher among those charged with violent offences [27]. When comparing male and female adolescents newly admitted into the criminal justice system, for those with more severe TBI, females were more likely to use mental health

services, whereas males were more likely to commit another offence [48]. This finding is consistent with previous research on general community populations where differences between males and females with TBI have been reported. In one recent study, it was reported that females were more likely to have internalizing disorders (depression, anxiety) and males having higher rates of eternizing disorders (offending behavior, property damage) [72]. These differences between males and females in terms of outcomes following TBI have significant implications in terms of the rehabilitation and support services required for each of the groups within the criminal justice system.

Conclusion

TBI has been associated with diminished coping skills, judgment and impulse control, difficulties with emotion recognition and poor emotional regulation. Given that these characteristics are also found among individuals who are charged with an offence, it is not surprising that the association between TBI and offending behaviors has become increasingly important to consider, both in terms of initial offending pathways and rehabilitation of such populations, particularly those within the criminal justice system. Research reviewed here suggests high prevalence of TBI among criminal justice populations, with up to 88% reporting a TBI event in some groups. Further, a history of TBI has been associated with increased rates of violent behavior, increased drug and alcohol use, deficits in cognitive functioning and increased mental health problems. It is evident from the high rates of TBI among criminal justice populations that there is a clear need for consideration regarding how this injury might impact on an individual's behavior while present within the criminal justice system, and how rehabilitation may have to be targeted if recidivism is to be successfully reduced.

However, from the extant research, it is not possible to accurately identify the prevalence of TBI among criminal justice populations, or whether TBI is in fact more frequent among these populations than within the general community, because community samples where self-report has been used and where a similar disadvantage is present, share similar reported prevalence rates. Further, there remains a need to more clearly clarify the direction of the relationship between TBI and offending behavior and its association with mental health outcomes.

Value of accurate identification of individuals with TBI

As outlined earlier, those within the criminal justice system with a history of TBI may be more likely to

be aggressive in challenging situations, and their ability to benefit from traditional rehabilitation programs requires evaluation in the context of cognitive or emotional problems that may exacerbate other issues [14,15]. It is, therefore, of value to identify a previous history of TBI and modify rehabilitation programs to maximize success. It is worth noting that for many individuals who experience TBI, even severe TBI, may not have previously had access to appropriate rehabilitation services following the acute period of recovery [73]. Further, it is not uncommon for children in particular to be expected to make a full and spontaneous recovery due to the notion of unlimited neuroplasticity [74,75]. Therefore, to be effective, any screening and subsequent intervention plan would have to be able to accommodate recent and historic TBI events. This notion of historic event is particularly important because a youth or adult with a history of an unrecognized severe brain injury who did not receive input would have an early trajectory of social and academic disadvantage [5].

While it is beyond the scope of this manuscript to discuss treatment plans, it is worth noting that organizations such as The Centers for Disease Control [76], brainline.org [77] and the North American Brain Injury Society [78] provide extensive information regarding interventions appropriate for individuals with TBI.

Future perspective

Unfortunately, accurate assessment of TBI prevalence rates among criminal justice groups is hampered by the reliance on self-report to ascertain cases of TBI, the use of inconsistent terminology and varying age ranges of the samples selected.

Further, because prevalence estimates for these populations rely on self-report and use inclusion criteria for defining TBI severity which differs from what is normally accepted for the general population, it is impossible to determine whether TBI is a risk factor for offending behavior and mental health problems. Moreover, little attention has been paid to whether an identified TBI event predates any offending behavior, making it difficult to evaluate the direction of the association between TBI and offending.

Moving forward, prevalence rates for individuals within the criminal justice system need to be validated against medical records. Using medical records would enable inclusion criteria that more closely resemble those used in community populations and would allow for direct comparison. It could be argued that not all offenders will seek medical attention for a TBI. However, there is no evidence that criminal justice populations are any less likely to seek medical attention than the general population. The greater problem remains that individuals do not have a good recall past TBI events and, perhaps more problematic, report false positives more frequently than true positives. In cases where only self-report is available, a careful approach to eliciting events is required. This approach should include the following: cueing of recall via multiple questions regarding how TBI events might have taken place; ensure the person has an understanding of different TBI terminology that may have been used to describe a past TBI injury; ensure that symptoms associated with TBI is elicited so that false understanding does not create false negatives, that is, the belief for some that a TBI requires LOC; ensure reported injury events are TBI and not confused with other injury events. No such instrument currently exists.

Further, to identify the direction of association information needs to be collected regarding when the TBI event occurred, and the timing of first offending behavior or contact with mental health services. Moreover, with the increasing numbers of females entered into the criminal justice system, it is essential that outcomes of TBI be considered for females separately to males to more clearly identify the particular needs of each group. Without more detailed examination of criminal justice populations, it will not be possible to illuminate the direction of association between TBI and offending behavior, and rehabilitation input will not be targeted to those who need it the most.

Executive summary

- There is increasing scrutiny to determine whether traumatic brain injury (TBI) is more prevalent among individuals within the criminal justice system. However, the current literature is fraught with methodological issues which are covered in the following areas:
    - Lifetime prevalence of TBI among individuals present within the criminal justice system highlighting methodological issue that explained variations.
    - TBI is not more prevalent among criminal justice populations, but comparable with similar subgroups in the general population.
    - There is inconsistent evidence as to whether TBI among criminal justice populations is associated with increased negative behavioral, psychological or social outcomes.
    - The possible link between increased prevalence of TBI, among criminal justice populations and mental health problems is obscured by insufficient information about the timing of injury.

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