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Traumatic brain injury: a potential cause of violent crime?

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Abstract

Traumatic brain injury (TBI) is the biggest cause of death and disability in children and young people. TBI compromises important neurological functions for self-regulation and social behaviour and increases risk of behavioural disorder and psychiatric morbidity. Crime in young people is a major social issue. So-called early starters often continue for a lifetime. A substantial majority of young offenders are reconvicted soon after release. Multiple factors play a role in crime. We show how TBI is a risk factor for earlier, more violent, offending. TBI is linked to poor engagement in treatment, in-custody infractions, and reconviction. Schemes to assess and manage TBI are under development. These might improve engagement of offenders in forensic psychotherapeutic rehabilitation and reduce crime.

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Contributors
WHW conducted the literature search. SF produced panel 1. TM produced panel 3. WHW produced the search strategy and panel 2. All authors contributed to writing the manuscript.

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Introduction

Crime has substantial human and economic costs. Crime peaks in late adolescence and early adulthood.1 Prolific offenders are early starters and commit 77% of crime.2 The lifetime costs of crime by a single prolific offender are in the range £1·3–2·3 million.3 Within a year of release from prison, 47% of adults, and 73% of those under 18 years, are reconvicted.4 In England, reoffending by recent ex-prisoners is estimated to cost £10–13 billion a year.5 There have been repeated calls to improve management of mental and physical health of prisoners—which might reduce crime.6 Leading theories for antisocial behaviour hold that so-called difficult temperaments and neuropsychological deficits contribute to life problems linked to crime.7–9 Traumatic brain injury (TBI) is very common in young people. TBI often leads to cognitive and personality issues that might increase risk of crime. The links between TBI and crime are complex. Those who offend could be risk takers with a low threshold for harm avoidance.10 However, a range of potentially criminogenic pre-injury factors could also be risk factors for, and be exacerbated by, TBI. Socioeconomic deprivation, male sex, and risk taking are co-associated with TBI and incarceration—and might simply occur by coincidence.11 However, TBI in groups already at risk could amplify deficits and erode coping responses and social networks.12 A TBI could compromise educational and employment capacity.13 We aim to review the evidence for how TBI could be related to crime. We will first describe TBI and its neuropsychological and behavioural consequences and then examine the studies suggesting links between TBI and crime. We then look at how prevalent TBI is in offenders—in children and young people, and in adults. Finally, we provide a summary of what can be done to address TBI in relation to crime, and areas for future research.

TBI

Mechanism of injury

TBIs involve an insult to the brain from an external mechanical force (eg, a blow to the head in an assault, a fall, or car crash). These injuries can lead to lacerations and bruising of the brain structures, especially around bony protrusions on the basal surface of the skull.14 Internal bleeding and secondary hypoxia often occur.15 There could be focal injury—usually within frontal and temporal areas—and diffuse injury due to shearing of white matter tracts—particularly related to rotational injury at high speed.16 In milder injuries, there is potential for disruption to axonal connectivity.16

Severity of injury

A Glasgow Coma Scale of 13 or above (out of a maximum of 15) denotes mild; a score of 9–12 is moderate; 8 or below severe. Post-traumatic amnesia or loss of consciousness (LOC), or both, can be used to gauge severity of a historic TBI. Mild TBI is considered to involve 0–30 min of LOC, 30 min and over being moderate to severe.17 A very mild injury —typically referred to as a “concussion” (with some disorientation at the time but no, or brief, loss of consciousness) rarely leads to permanent brain changes. With increased severity there is a higher risk of chronic problems. With moderate to severe TBI there is,

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more likely than not, long-term neurocognitive, behavioural, and psychiatric disturbance (panel 1).

Incidence, prevalence, and risk factors

TBI is the largest cause of mortality and morbidity in children and young people. It has been called a silent epidemic—as it is often not recognised by social and health-care professionals.26 There is an aggregate hospitalised (meaning those diagnosed at emergency department [ED] and not admitted as well as those admitted) plus fatal TBI incidence rate of about 235 per 100 000 people across European countries,27 with TBI severity ratio of hospitalised patients reported as 22:1·5:1 for mild versus moderate versus severe cases, respectively. In middle-income and low-income countries, three times as many people can suffer TBIs compared with high-income countries.28 TBI frequently occurs from falls, sporting injuries, fights, assaults, and road accidents. Rates of injury are high, and equal, for both sexes in the very young (under 5 years of age), while adolescents and young adult males are the group most at risk.29 In a general population, the lifetime prevalence of a TBI —with some LOC—has been estimated to be around 8%30 and 12%31—with men having twice the odds of having had a TBI compared with women.31 TBI has a strong socioeconomic gradient—disadvantage being a major risk factor.29

Neuropsychological functions and sociobehavioural problems

The neuropsychological effects of TBI tend to be amnestic and executive disorders (poor memory, attention, concentration, and planning). Deficits in emotional regulation—characterised by impulsiveness and poor social judgment—are common. Milder TBIs can lead to problems in attentional control and inhibitory functions.32 Injury to frontal systems can lead to increased risk of impulsive aggression, poor decision making, and lack of control of social behaviour.33,34 For example, veterans from the Vietnam War with injuries to the frontal ventromedial cortex (the part of the frontal cortex involved in fear and risk) were rated as more aggressive and violent compared with non-injured controls and patients with lesions in other brain areas.35

Self-regulation and the developing social brain

The early start of a large number of offenders could be due to immaturity or vulnerability of brain systems for social cognition, or both. The so-called social brain system is complex and distributed.36 It comprises systems for deducing emotions from facial expressions and vocal tone for reading others' minds for intentions, and responding appropriately.37 These key abilities for socialisation have differential developmental trajectories.38 Reward systems become mature in the mid-teens with increased sensation-seeking behaviour. Meanwhile, areas for deliberate control of impulses and making judgments—the dorsolateral prefrontal cortex—reach maturity in the late teenage years.39 Adolescents and young adults are, consequently, poorer than adults at responding on problem-solving tasks under emotional demand, particularly in social contexts, which increases risk-taking behaviour.1,37,40–43

TBI can disrupt development of these systems for social interaction and contribute to behavioural problems. Max and colleagues44 followed up 94 children aged 5–14 years post

TBI. Personality change occurred in 59% of those with severe TBI (22/37) and 5% of those with mild/moderate TBI (3/57). Emotional lability, aggression, and disinhibition were most common. In a related study (n=177), children with such personality changes were found to have lesions of the dorsal prefrontal cortex.45 More recently, they found novel psychiatric disorders in 25 (36%) of 70 children after mild TBI;46 attention-deficit hyperactivity disorder (ADHD), personality change, and oppositional defiance being most common. Pre-existing conditions, such as ADHD, are risk factors for TBI.47 Interestingly, children with ADHD secondary to TBI tend to have worse dual attention and working memory compared with those with non-injury ADHD and children with TBI only.47

Changes in behaviour post-TBI could have detrimental effects on key social roles. In a study in children (n=850) at risk of high school dropout, it was found that head injury before young adulthood was associated with interpersonal violence (controlling for alcohol use, marijuana use, delinquency, and observing violence).48 Two linked cohort studies showed that adults who had had TBI as children were significantly poorer at emotion perception than controls and had externalising behaviour, poor pragmatic communication ability, and greater trouble with law enforcement.49,50

Injury in childhood and adolescence can, therefore, lead to impulsivity, poor sociocommunication skills, and concomitant externalising behaviours. Injury at this life stage could well disrupt the development of prosocial life roles. Such patterns of behaviour could underlie a drift from the classroom to the courtroom.

Epidemiological studies on TBI and crime

Birth cohort and data linkage studies in adolescents and adults indicate that TBI is associated with increased risk of perpetrating crime. However, although these studies implicate links between TBI and crime, there is a lack of clarity on actual causal mechanisms.

Birth cohort—In a study of around 12 000 males in Finland,51 TBI during childhood or adolescence was associated with a four times increased risk of mental disorder with coexisting offending in adulthood. TBI before 12 years of age was linked to earlier onset of criminality. There was no adjustment for familial and socioenvironmental confounds. Those injured younger might have had stronger risk factors for earlier TBI and criminality. In a study in New Zealand,52 in which 1265 children were followed up to age 25 years, a TBI group, relative to control, were more likely to be arrested. Although when alcohol and drug dependence were controlled for, TBI was no longer associated with crime in those who were injured between the ages of 0 and 5 years. Early substance use could be a mediating factor for crime in those injured at a very young age. In a birth cohort study in southwest England, 53 a TBI group—categorised as mild (n=800)—was at increased risk of criminal behaviour by age 17 years compared with the non-TBI group (n=8307; unadjusted odds ratio [OR] 1·6, 95% CI 1·2–2·2). Associations were confounded by substance use. Furthermore, the TBI group were no different to an orthopaedic injury group (n=2305; adjusted OR 1·1, 95% CI 1·1–1·6). However, TBI was linked to hazardous alcohol use, externalising symptoms, conduct problems, and ADHD.

The evidence for TBI leading to crime from birth cohort studies is, therefore, mixed. There is a suggestion of a latent factor—linked to being injury prone—in orthopaedic and TBI groups, which might confer risk for crime. However, the measures used for TBI vary markedly across these studies. The Finnish study used data from health records—with high sensitivity and specificity—whereas the southwest England study relied on two self and carer reports of mild TBI. As such, the former included moderate to severe injury—which is more likely to be associated with problem behaviour in the long term—whereas the latter included only mild injury—with less substantial, life-changing, consequences.

Data linkage and population studies—Broadly consistent findings in four major data-linkage studies have indicated that TBI does increase criminality, although some preinjury characteristics remain important predictors of crime.54 In northern Finland, adolescents admitted to psychiatric care who had had a TBI were at increased risk of any criminality (by 6·8 times), conduct disorder (5·7 times), and concomitant criminality and conduct disorder (18·7 times) compared with those with no TBI.55 They had also committed significantly more violent (42·9% *vs* 9·1%) and non-violent crimes (29·4% *vs* 6·8%) crimes. However, reverse causality was possible. One of the most compelling studies indicating a risk of crime post-TBI is a 35-year, retrospective, total population study of Swedes.56 Fazel and colleagues56 found that 2·3% of population controls had committed violent crimes. By contrast, of TBI cases (a total of 22 914), 8·8% had committed violent crimes. This finding corresponded to a substantially increased risk of violent crime in the TBI population (adjusted OR 3·3, 95% CI 3·1–3·5). Risk was attenuated when cases were compared with unaffected siblings (adjusted OR 2·0, 1·8–2·3), who would have shared similar genetic, social, and economic backgrounds. Sibling controls were also examined in a retrospective cohort data linkage study in Western Australia.57 Hospital-recorded cases of TBI (n=7694) were compared to matched cohort (n=22 905) and full-sibling controls. TBI was associated with increased risk of all offending in males (hazard ratio [HR] 1·6, 95% CI 1·5–1·7) and females (1·5, 95% CI 1·3–1·8). When same-sex full-sibling controls were used in the adjusted analyses, increased risk of offending was evident only among males with TBI (HR 1·7, 95% CI 1·3–2·3). For violent convictions, relative to the general community, TBI was also associated with increased risk in men (HR 1·7, 95% CI 1·4–1·9) and women (1·7, 1·2–2·5). Analysis comparing full siblings with, and without, TBI showed that TBI was associated with violent offending only in men (HR 1·9, 95% CI 1·2–3·0). In these analyses, potential confounders (aboriginal background, substance abuse, social disadvantage, etc) were controlled for. A recent large-scale data-linkage cohort study58 of 1·4 million Ontarian adults also indicated that TBI is linked to more serious offending. Data on people aged 18–28 years who attended emergency departments were linked to records from correctional services. Incarceration was to a federal facility (most likely for more serious or repeated offending). Analyses showed that TBI—in men and women—was associated with a subsequent increased risk of incarceration (HR 2·5, 95% CI 2·2–2·8). Potential confounding factors were controlled for in models (eg, socioeconomic, substance misuse, psychiatric disorder). By contrast, a prospective cohort study54 with 6315 adult participants (which reduced to n=2690 at 5 years postinjury) from a US-based TBI Model System National Database found that premorbid variables, especially pre-TBI offending, were strongly linked to post-TBI arrests. However, higher numbers of post-TBI arrests were predicted by loss of

consciousness (≥24 h) combined with retention of motor functions. Participants had moderate to severe TBI (greater than 30 min LOC) and were predominantly over 25 years of age (a stage of life less likely to be a risk period for crime). That the participants had been in a TBI model system might have had a protective effect on behaviour.

TBI might be, at the very least, a prominent marker for a range of issues that indicate a risk for crime. In addition, considering the range of evidence, across age groups, populations, and jurisdictions, these studies indicate that TBI is an independent risk factor for crime. In the very young, it could lead to later drug and alcohol misuse, which, in turn, increases likelihood of crime. In those injured after 5 years of age, including adults, TBI appears to be linked to increased likelihood of offending. However, established criminogenic risk factors are still important. TBI could add to greater risk of criminality by increasing likelihood of problem behaviour and eroding capacity for self-regulation and socialisation.

TBI prevalence studies in offender populations

In this section, we examine the prevalence, and associated features, of TBI in offenders. We consider how TBI could be linked to neuropsychological problems, mental health and drug and alcohol misuse issues, poor response to forensic rehabilitation, and recidivism.

Presence of neurological abnormalities

Two recent CT and MRI neuroimaging studies in adults in Germany have indicated higher levels of brain anomalies in offenders. Schiltz and colleagues,59 in a study of 287 male prison inmates, found that violent prisoners had significantly more morphological abnormalities than non-violent prisoners or controls (42% in violent prisoners *vs* 26% *vs* 8% respectively). They noted how the areas affected in the violent offenders were those typically associated with empathy. Witzel and colleagues60 found half of 148 patients in a secure mental health institution displayed signs of brain pathology compared with 8% in non-criminal controls. We note these studies were with highly selective samples, and causes of lesions were not known. We cannot know whether being violent led to injury or vice versa.

Youth populations

In incarcerated young people, TBI appears to be prevalent and linked to greater risk of violence. However, there are important comorbid and adversity-related factors that are criminogenic. Adversity could relate to trauma, severe economic disadvantage, parental loss, abuse, and neglect.61

In a meta-analysis11 of studies of TBI in juvenile offenders, nine studies were identified. The rate of TBI (with a history of LOC) across nine studies was approximately 30%. This is high relative to the general population. In the five studies that used a control group, a summary OR of 3·37 was calculated, which suggests that juvenile offenders are substantially more likely to have a TBI compared with controls.

There are few studies on severity of TBI, comorbid conditions, and patterns of crime. Williams and colleagues62 assessed 197 young incarcerated male offenders (average age 16 years)—60% reported a head injury. There was an LOC in 46% of the sample, and 16%

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reported moderate or severe TBI (defined as LOC for 10 min to 6 h, or 6 h or more).63 The main cause of injury was violence. Three or more TBIs were associated with greater violence. TBI was linked to mental health problems, misuse of cannabis, and more convictions. In a related study, Davies and colleagues63 found that complicated mild TBI (LOC of 10–30 min, or repeated injury) was associated with greater degree of ongoing postconcussion syndrome symptoms (forgetting, headaches, etc)—controlling for drug and alcohol misuse. LOC history was correlated with younger age of first conviction (12 *vs* 13 years). Similarly, in the USA, Perron and Howard64 found that 18% of 720 inmates (average age 15·5 years) had TBIs where they were unconscious for more than 20 min. Male sex, psychiatric diagnosis, and earlier onset of criminal behaviour and substance use were associated with brain injury.

Adversity and comorbid issues, when assessed, are very common in young offenders. Chitsabesan and colleagues65 reported a study with incarcerated adolescents in England (93 boys aged 15–18 years). 82% reported a TBI and 18% had moderate–severe current postconcussion symptoms. Those with moderate to severe TBI (msTBI) compared to no or mild TBI (NoM TBI) reported common comorbid problems: ADHD (29% of msTBI, 20% of NoM TBI); speech and language impairments (msTBI 36%, NoM TBI 41%); and alcohol (msTBI 71%, NoM TBI 58%) and cannabis misuse problems (msTBI 86%, NoM TBI 84%). The msTBI group were significantly more likely to have previously been in care (64% *vs* 34%), and to be at current risk of deliberate self-harm (57% *vs* 43%) and suicidality (50% *vs* 24%). A study by Vaughn and colleagues66 in the USA with adjudicated adolescents (n=1345, aged on average 16 years, mostly [86%] male), also found that those with TBI had higher scores for a range of comorbid problems—psychopathy, moral disengagement and impulsivity, bullying, peer delinquency, violent victimisation, and witnessing violence.

Adult populations

A meta-analysis of lifetime prevalence of TBI in incarcerated adults versus the general population indicates that it is significantly higher in the offenders.67 The unweighted pooled prevalence for TBI across 5049 participants in 24 studies was 51%. Both male and female groups were affected. There also appears to be a severity effect. In a study in the USA,68 for example, on the lifetime prevalence of TBI in prisoners, 65% of males and 72% of females reported one TBI with alteration of consciousness. Longer LOC was associated with more symptoms. In the UK, of 200 adult male prisoners, 60% reported a TBI of some form.69 Moderate to severe TBI (LOC of 10 min or more) was reported by 17%. Those with a self-reported history of TBI were, on average, 5 years younger at the age of first prison sentence than uninjured (age 16 compared to 21 years) and had higher rates of reconviction. Perkes and colleagues,70 who examined 200 men in custody (aged 30 years) and 200 non-offenders (aged 43 years) in the community—from a matched (by residence) background—found that TBI was more common among prisoners (82% *vs* 72%). There was a higher proportion of prisoners with histories of LOC (65% *vs* 35%). Prisoners had more multiple TBIs (42% *vs* 15%). Assault was the most common cause of injury in prisoners whereas sporting injury was in the community sample. The offender group also reported significantly greater ongoing psychological effects of injury, such as headaches, memory problems, and anger.

This pattern suggests a history of TBI involving high speed mechanisms and actual brain changes in offenders.

This theme of consequential injury is consistent with a trend for prisoners with TBI to have been shown to have greater levels of neuropsychological deficits and treatment failure. Pitman and colleagues71 compared 139 male prisoners with 50 prison controls without TBI. They found no differences for premorbid intellectual functions. However, those with TBI were worse on current functions, particularly executive skills. Severity of TBI was associated with greater impairment. The TBI group had greater prevalence of violent crime (60% *vs* 38%). Fishbein and colleagues72,73 assessed executive functioning in 224 participants of a forensic rehabilitation programme. Of these, 28·3% (n=71) reported head injury (3 min of LOC). Those with TBI had more problems in executive control and made fewer gains in treatment. Dysexecutive disorders were linked to dropout from treatment and to less improvement on aggressive reactivity. Those with TBI were more likely to have a history of physical, emotional, and sexual abuse.

TBI also appears to be associated with infractions in prison and reconviction. Shiroma and colleagues,74 in a US state-wide study over 11 years using linked hospital and justice datasets of 17 569 inmates, found that males and females with TBI had significantly higher rates of violent infractions. Ray and Richardson75 did a longitudinal, prospective, follow-up study of 151 inmates released from incarceration during a period of 12–30 months. At 12 months postrelease, 63% of those without TBI had not recidivated, whereas 48% of TBI had not. The TBI group had a regression model hazard rate of 1·57 greater than non-TBI for recidivism.

TBI, as we have seen, occurs within a constellation of socioadversity factors. This is particularly evident in studies with girls and women. Of 113 female prisoners in the USA, Brewer-Smyth and colleagues76 found that 42% had TBI histories, and those who had committed violent offences had suffered an average of two TBIs. Domestic abuse, previous suicide attempts, and TBIs with LOC were all associated with current violent convictions. Similarly, Colantonio and colleagues77 found that females with TBI who offend had suffered more early physical and sexual abuse than those without TBI. Abuse, of various forms, could be associated with concussive blows or TBIs. Such injuries could complicate the experience of post-traumatic stress disorder (PTSD), with survivors having patchy recall of events.78

Economic costs

A UK charity, Centre for Mental Health, recently analysed the cost of TBI, including costs relating to crime.3 Calculations were based on cases of TBI with hospital admission (classified as mild or moderate). Modest likelihood risk ratios were used to predict the additional risk of offending post-TBI. On average, in a person representative of the general population aged 15 years, the lifetime costs of TBI would be around £155 000 per case, including £95 000 for non-crime costs (health care, lost earnings, etc) and £60 000 for the costs of additional offending. For a young person already in the criminal justice system, the

lifetime costs increase to around £345 000 per case, reflecting the much higher costs in those already on a likely trajectory into persistent offending.

Opportunities for change

A range of measures could reduce the risk of crime following TBI. First, any form of neurorehabilitation could offset the risk of violent crime.79 Second, improved linkage between emergency departments, community mental health services, general practitioners, and school systems might lead to early identification and management of TBI in children and young people, particularly in lower socioeconomic areas. This approach could reduce the chances of school exclusion and social isolation. Third, on a person's entry into the justice system (police, courts, or admission to probation or secure care), there is an opportunity to deliver routine screening for TBI and provision of treatment options. For young people in courts in the UK there is now recognition that TBI should be taken into account in sentencing.80 There are initiatives in England that allow screening for neurodisability in entrants into youth secure estate (secure children's homes, secure training centres, and young offender institutions). There have also been pilot projects to assess for TBI and other neurodisabilities in young adult and adult prisons.71,81 Fourth, provision of brain injury link-workers within prisons to enable screening and support for those with TBI, and training and support for staff, has been shown possible and beneficial.65 Through such initiatives, forensic rehabilitation could be enhanced with interventions to manage the cognitive and behavioural issues stemming from TBI. One illustration of how this might work is in a non-TBI study in which medication for ADHD in offenders led to a 30% reduction in criminality on release—possibly owing to improved impulse control.82 In the UK, Parliamentary bodies have noted the need to take account of TBI in the criminal justice system (panels 2 and 3).83,84

Research directions

The causal mechanisms that link TBI and crime are unclear. It might be supposed that having a TBI would typically lead to—or exacerbate—problems in behavioural self-regulation and mood. For example, aggressive behaviour has been shown to be increased after TBI, but pre-TBI aggression is also a risk factor for post-TBI aggression.85 Higher quality research is needed to examine these links while accounting for the various factors that could confound this association.

It is clearly important to address some of the weaknesses in studies reviewed. Birth cohort, data-linkage, and prevalence studies lack agreed definitions or criteria for identifying TBI. In many studies there are binary yes or no classifications of presence or absence of TBI, and often there is no measure of injury severity. Furthermore, measures of crime are often limited (eg, only the type of sentence given). Studies also tend to be cross-sectional and lack verified medical records. They rarely have non-offending control groups. Although it is worth noting that one study with young offenders used self-reports and medical records and found that rates of injury were consistent.65 Similarly, one study with adults found 70% agreement between self-reported and medically recorded TBI.86 However, future research is needed with prospective, longitudinal designs, with well validated and agreed TBI criteria.

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They should also have appropriate control groups with measures of actual criminal behaviour, such as from police records.

It is particularly important that future studies are designed to characterise the nature and severity of neurotrauma in offenders versus controls. Ideally, there should be neuroimaging, such as diffusion tensor imaging, alongside measurement of chronic TBI biomarkers such as tau.87 Such analyses would allow a better understanding of the underlying pathology of TBI within offenders and offer windows for novel treatment options to be developed.88

Given the high levels of preinjury developmental adversity, comorbid neurodisability, and mental ill-health in the populations studied, it is vital to establish how much of current functioning and behaviour is determined by TBI or these other factors, or both.89 Of particular importance is a need to explain how TBI is situated within the criminogenic life histories of offenders. Crucially, offenders often report childhoods characterised by harsh or inconsistent parenting and abuse—with angry and coercive role models for emotional regulation.90,91 Such environments could underlie an adaptive behavioural response of hypervigilance for threat92–94 and tendencies of being insensitive to others and impulsive. 63 There is evidence that adversity is associated with neurological anomalies in exposed young people compared with controls.95 Furthermore, the lives of offenders, as illustrated by the levels of injuries sustained (eg, in fights and road accidents), would suggest a role for current PTSD in some form in this population.96 PTSD could contribute to problems with hypervigilance and impulsivity linked to criminality.97 A more detailed account of the legacy of such a trauma history, combined with TBI, would be important for determining how best to reduce the risk of crime.

Given the large populations of the criminal justice system, it is important to determine what forms of screening could be done quickly and reliably (at arrest, court, prison, release, and probation), and how those data could be used to guide interventions. This method could be tailored for particular regimens and within specific facilities (eg, segregation, close supervision, or health care). The use of sensitive screening tools could generate data for linkage (such as through criminal justice, health, and education) to identify trends in crime in relation to TBI. Furthermore, given that TBI appears to increase the chances of violent crime, it is important that it is considered as a factor for predicting future violence. Scalable tools such as OxRisk, enable stratification of prisoners into high, medium, and low risk groups.98 Adding TBI as a factor in the model could increase predictive accuracy and enable enhanced support plans to reduce crime risk. Pharmacoepidemiology offers one approach to identify treatment strategies in the absence of RCT evidence.99

Conclusions

TBI appears to be associated with earlier age of incarceration, increased risk of violence, and more convictions. Neurological abnormalities are common in offenders. Brain functions, in areas important for social functioning, such as impulse control and empathy, appear compromised. In those in custody, complicated mild TBI or moderate to severe head injury is prevalent in one to two in ten people, and another three or four in ten could have a milder form of TBI. Neuropsychological dysfunction is linked to violence, infractions in prison,

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poorer treatment gains, and reconviction. Life histories of abuse, neglect, and trauma appear particularly elevated in those with TBI versus those without TBI histories, as are ongoing mental health and drug and alcohol problems. Young offenders with TBI are particularly at risk of self-harm and suicidal behaviour. TBI could amplify any neurocognitive issues due to adverse life events. People with TBIs are incarcerated at high cost in facilities that might not be well placed to address their needs. There has been an assumption that TBI was just a coincidental occurrence in the lives of risk takers: people who were premorbidly set to be on a trajectory towards crime. But as we have shown in this review, the research evidence suggests otherwise. Addressing TBI offers a means not only to improve the lives of those who offend, but also, crucially, to reduce crime.

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Panel 1

Traumatic brain injury (TBI) and risk of psychiatric morbidity

Systematic reviews and large cohort studies have identified that psychiatric morbidity is high in individuals with TBI, with some finding that TBI increases risk.18 A 2009 review19 reported that depression was increased after a TBI, but that the information for other psychiatric disorders was limited. Another review20 has reported rates of post-traumatic stress disorder (PTSD) in 5–7% of individuals with mild TBIs.

Since these reviews, high-quality cohort studies have found increased risk of new psychiatric disorders, including PTSD, panic disorder, social phobia, and agoraphobia, with 22% of individuals having new diagnoses.21

Other relevant research has been done in the USA, where risk of incident psychiatric disorders was increased (relative risk [RR] 2·8, 95% CI 2·1–3·7),22 but this was not found for schizophrenia in Denmark.23 A recent large population-based cohort study24 using sibling controls reported new diagnoses of substance use and depression to be higher in those with TBIs than sibling controls, and higher risk of premature mortality (odds ratio 2·6, 95% CI 2·3–2·6) and suicide (2·3, 1·9–2·9) compared with siblings who did not have diagnoses of any head injury. A recent investigation of all individuals,25 identified using health-care registers, who sustained head injuries until the age of 25 years in Sweden found that risk of any inpatient psychiatric hospitalisation (RR 2·0, 95% CI 1·9–2·0) and any psychiatric episode (1·5, 1·5–1·6) was higher than in population controls. These risks were higher when head injury was sustained at older ages, and when it was more severe.25

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Panel 2

Justice Committee Report, UK Parliament82,83

The Justice Committee of the Parliament of the UK and Northern Ireland recently reported that: “We received compelling evidence that another important consideration for young adults in the criminal justice system is the potential presence of atypical brain development….those who persist in criminal behaviour into adulthood are more likely to have neuro-psychological deficits, including cognitive difficulties with thinking, acting, and solving problems, emotional literacy and regulation, learning difficulties and language problems associated with Attention Deficit Hyperactivity Disorder (ADHD), autism, learning and language disorders and head injuries…[furthermore] deficits, particularly ADHD and traumatic brain injury (TBI, an impairment to the brain from an external mechanical force) are associated with more violent offending” (p 9). The Committee also note that: “Navigating the [justice] system is particularly challenging for those with neuro-disabilities [which] impact on their experience of the system and their capacity to desist from crime” (p 56). They recommend a range of initiatives which include: screening, awareness raising of staff, specialist support, and data gathering for commissioning.

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Panel 3

Review of services for people with brain injury in the justice system, commissioned by the Justice Committee, Scottish Parliament83

- A recent government report outlines a service pathway for people with brain injury in the criminal justice system in Scotland1
- The pathway extends from police custody through to probation, utilising identification and screening to triage to appropriate services
- Preliminary evidence obtained in the course of the report indicated a four-times greater risk of a history of admission to hospital with head injury than in matched general population controls
- A need for specialised secure forensic provision for people with brain injury was identified
- Linkage between brain injury services and the criminal justice service was found to be poor
- A need for effective education and intervention packages was identified

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Search strategy and selection criteria

We searched Ovid, MEDLINE, and Ovid-PsycINFO from April 15, 2007, to April 15, 2017, using the search terms: “TBI” or “Head Injury”, “Traumatic Brain Injury, Crime * [criminal], Offend, Prison, Juvenile + Delinquent”. English language only was used. We identified 806 articles, of which 102 were relevant to traumatic brain injury and crime.