# Traumatic Brain Injury: A potential cause of violent crime?

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Summary:

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 behavior and increases risk of behavioral disorder and psychiatric morbidity. Crime in young people is a major social issue. “Early starters” often continue for a lifetime. A substantial majority of young offenders are re-convicted 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 poorer engagement in treatment, in-custody infractions, and re-conviction. Schemes to assess and manage

TBI are under development. These might improve engagement of offenders in forensic psychotherapeutic rehabilitation and reduce crime.

## Introduction:

Crime has significant 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 (see (3)). Within a year of release from prison, 47% of adults, and 73% of those under 18 years, are reconvicted.(4) In England re-offending 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 anti-social behaviour hold that "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 which may increase risk of crime. The links between TBI and crime are complex. Those who offend may be "risk takers" with low "bar" for harm avoidance.(10) However, there are a range of pre-injury factors that could be "criminogenic", which may 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 may simply occur by coincidence.(11) However, TBI in already "at risk" groups may amplify deficits and erode coping responses and social networks.(12) A TBI may compromise educational and employment capacity.(13) In this article we aim to review the evidence for how TBI may be related to crime. We will first describe TBI and its neuropsychological and behavioural consequences. There follows an examination of the studies suggesting links between TBI and crime. We then look at how prevalent TBI is in offenders – in children and young people (CYP) and in adults. We then provide a summary of what can be done to address TBI in relation to crime, and areas for future research.

[INSERT BOX 1 RE: LITERATURE REVIEW PROCESS HERE]

## Traumatic Brain Injury:

*Mechanism of injury:* TBIs involve an insult to the brain from an external mechanical (e.g. a blow to the head in an assault, a fall, or car crash). These injuries may 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 occurs.(15) There may 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:* Glasgow Coma Scale (GCS) 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 (PTA) and/or Loss of Consciousness (LOC) can be used to gauge severity of a historic TBI. Mild TBI is considered to involve 0-30 minutes of LOC, and 30 minutes 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, more likely than not, long term neurocognitive, behavioural and psychiatric disturbance.

[INSERT BOX 2 HERE RE: PSYCHIATRIC MORBIDITY POST TBI]

*Incidence, Prevalence & 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.(18) There is an aggregate hospitalized plus fatal TBI incidence rate of about 235 per 100,000 people across European countries. (19) With TBI severity ratio of hospitalized patients reported as 22:1.5:1 for mild vs. moderate vs. severe cases, respectively. In middle and low income countries three times as many people may suffer TBIs.(20) 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), whilst adolescents and young adult males are the most "at risk" group.(21) In a general

population, the lifetime prevalence of a TBI – with some LOC- has been estimated around 8%(22) and 12%(23) - with men having twice the odds of having had a TBI compared to women.(23) There is a strong socio-economic gradient to TBI - disadvantage being a major risk factor.(21)

Neuropsychological functions and socio-behavioural 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 may lead to problems in attentional control and inhibitory functions.(24) Injury to "frontal" systems may lead to increased risk of impulsive aggression, poor decision-making, and lack of control of social behaviour.(25) (26) For example, veterans from the Vietnam War with injuries to frontal ventromedial cortex (part of frontal cortex involved in fear and risk) were rated as more aggressive and violent compared to non-injured controls and to patients with lesions in other brain areas (27).

*Self-regulation and the developing "Social Brain":* That a preponderance of offenders "start early" may be due to immaturity and/or vulnerability of brain systems for social cognition. The "social brain system" is complex and distributed.(28) It comprises systems for deducing emotions from facial expressions and vocal tone for "reading" others' minds for intentions, and responding appropriately.(29) These key abilities for socialisation have differential developmental trajectories.(30) Reward systems become mature in mid-teens with increased sensation-seeking behaviour. Meanwhile areas for deliberate control of impulses and making judgments - the dorso-lateral prefrontal cortex – reaches maturity in the late teenage years.(31) Adolescents and young adults are, consequently, poorer at responding on problem solving tasks under emotional demand, particularly in social contexts, which increases risk taking behaviour.(29, 32) (33) (34) (35) (1)

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

post TBI.(36) 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 (37). More recently they even found novel psychiatric disorders (NPD) in 25 of 70 children (36%) after mild TBI.(38) ADHD, "personality change", and oppositional defiance being most common. Pre-existing conditions, such as ADHD, are risk factors for TBI (39). Interestingly, it has been shown that children with ADHD secondary to TBI tend to have worse dual attention and working memory compared to those with non-injury ADHD, and to children with TBI only.(39)

Changes in behaviour post TBI may have detrimental effects on key social roles. In an study on children (N=850) at risk for high school drop-out it was found that "head injury" before young adulthood was associated with interpersonal violence (controlling for alcohol use, marijuana use, delinquency, and observing violence).(40) Two, linked, cohort studies showed that adults who had had TBI as children were significantly poorer at emotion perception than controls and had externalizing behaviour, poor pragmatic communication ability, and greater "trouble with the law". (41, 42)

Injury in childhood and adolescence may, therefore, lead to impulsivity, poor socio-communication skills, and concomitant "externalising" behaviours. Injury at this life stage may well disrupt the development of pro-social life roles. Such patterns of behaviour could underlie a drift "from the classroom to the courtroom".

*Epidemiological Studies on TBI & Crime:*

There are birth cohort and data linkage studies in adolescents and adults that indicate that TBI is associated with increased risk of 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, TBI during childhood or adolescence was associated with a fourfold increased risk for mental disorder with coexisting offending in adulthood.(43) TBI before age 12 was linked to earlier onset of criminality. There was no adjustment for familial and socio-environmental confounds. Those injured younger may have had stronger risk factors for earlier TBI and criminality. In a study in New Zealand, in which 1265 children were followed up to age 25, a TBI group, relative to control, were more likely to be arrested (44). Although, when alcohol and drug dependence were controlled for, TBI was no longer associated with crime in those who were injured between 0 and 5. Early substance use may be a mediating factor for crime in those injured at a very young age. In a birth cohort study in South West England (SWE), a TBI group – categorised as "Mild" (n=800) - was at increased risk criminal behaviour by age 17 compared to non-TBI group (n = 8307) (Unadjusted OR 1.6 (1.2-2.2). (45) Associations were confounded by substance use. Furthermore, the TBI group were no different to an orthopaedic injury group (n: 2305) ((Adjusted OR=1.1 (1.1-1.6)). TBI was, though, linked to hazardous alcohol use, externalising symptoms, conduct problems, and ADHD.

The evidence for TBI leading to crime from birth cohort studies are, 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, there is marked variation in the measures used for TBI across these studies. The Finnish study used data from health records - with high levels of sensitivity and specificity - whilst the SWE study relied on 2 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 - whilst the latter included only mild injury - with less significant, life changing, consequence.

**Data linkage & Population Studies:** Broadly consistent findings, in 4 major data-linkage studies, have indicated that TBI does increase criminality. Although some pre-injury characteristics remain important predictors of crime.(46) In Northern Finland, adolescents admitted to psychiatric care who had had a TBI were at increased risk of

“any criminality” (6.8-fold) conduct disorder (5.7-fold) and concomitant criminality and conduct disorder (18.7-fold) compared to those with no TBI.(47) 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 (48). Fazel and colleagues found that 2.3% of the population controls had committed violent crimes. In contrast, of TBI cases (a total of 22,914), 8.8% had committed violent crimes. This corresponded to a substantially increased risk of violent crime in the TBI population (adjusted odds ratio [aOR] = 3.3, 95% CI: 3.1–3.5). Risk was attenuated when cases were compared with unaffected siblings (aOR = 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.(49) Hospital recorded cases of TBI (n=7,694) were compared to matched cohort (n=22,905) and full sibling controls. TBI was associated with increased risk for all offending in males (HR = 1·6 CI 1.46 to 1.72) and females (HR = 1·5 CI 1.28 to 1.81). When same-sex full-sibling controls were used in the adjusted analyses, increased risk of offending was evident among TBI males only (HR = 1·7 CI 1.31-2.18). For violent convictions, relative to the general community, TBI was also associated with increased risk in men (HR = 1·65 CI 1.42 to 1.92) and women (HR = 1.73 CI 1.21 to 2.47). Analysis comparing full siblings with, and without, TBI, showed that TBI was only associated with violent offending in men (HR = 1.9 CI 1.20-3.00). In these analyses potential confounders (aboriginal background, substance abuse, social disadvantage etc.) were controlled for. A recent large scale data-linkage cohort study of 1.4 Million Ontarian adults also indicated that TBI is linked to more serious offending.(50) Data on persons aged 18-28 who attended Emergency Departments were linked to records from correctional services. Incarceration was to federal facility for (likely for more serious or chronic offending). Hazard ratio analyses showed that TBI – in men and women - was associated with a subsequent HR 2.5 (CI: 2.2-2.8) increased risk of incarceration. Potential confounding factors were controlled for in models (e.g. socio-economic, substance misuse, psychiatric disorder etc.). In contrast, a prospective cohort study with 6315 adult participants (which reduced to *N* = 2690 at 5 years post injury), from a US based TBI Model System National Database,

found that Premorbid variables, especially pre-TBI offending, were strongly linked to post-TBI arrests (46). Higher numbers of post-TBI arrests were, though, predicted by loss of consciousness (≥24 hours) combined with retention of motor functions. Participants had Moderate to Severe TBI (greater than 30 minutes LOC) and were predominantly over age 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 may be, at the very least, a prominent "marker" for a range of issues that indicate a risk for crime. Furthermore, 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 may lead to later drug and alcohol misuse, which, in turn, increases chances of crime. In those injured after 5, including adults, TBI appears linked to increased likelihood of offending. However, established criminogenic risk factors are still important. TBI may add to greater risk of criminality by increasing likelihood for 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. In particular, how TBI may be linked to neuropsychological problems, mental health and drug and alcohol misuse issues, poor response to forensic rehabilitation, and recidivism.

*Presence of neurological abnormalities:* There have been two recent CT and MRI neuroimaging studies in adults in Germany indicating higher levels of brain anomalies in offenders. Schiltz et al, 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).(51) They noted how the areas affected in the violent offenders were those typically associated with empathy. Witzel et al (52) found half of 148 patients in a secure mental health institution displayed signs of brain pathology compared to 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 co-morbid and adversity related factors that are criminogenic. Adversity could relate to trauma, severe economic disadvantage, parental loss, abuse and neglect.(53)

In a meta-analysis of studies of TBI in juvenile offenders 9 studies were identified. (11) The rate of TBI (with a history of LOC) across 9 studies was approximately 30%. This is high relative to the general population. In the five studies that used a control group a summary odds ratio of 3.37 was calculated, which suggests that juvenile offenders are significantly more likely to have a TBI compared to controls.

There are few studies on severity of TBI, comorbid conditions, and patterns of crime. Williams et al. assessed 197 young incarcerated male offenders (average age 16) - 60% reported a 'head injury'.(54) There was a LOC in 46% of the sample, and 16% reported Moderate or Severe TBI (defined as LOC for 10 minutes to 6 hours or 6 hours or more).(55) The main cause of injury was violence. Three or more TBIs was associated with greater violence. TBI was linked to mental health problems, misuse of cannabis, and more convictions. In a related study Davies et al. found that complicated MTBI (LOC of 10 to 30 minutes, or repeated injury) was associated with greater degree of on-going PCS 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, Peron and Howard found that 18% of 720 inmates (average age 15.5) had TBIs where they were unconscious for more than 20 minutes.(56) Male gender, psychiatric diagnosis, and earlier onset of criminal behaviour and substance use were associated with brain injury.

Adversity and co-morbid issues, when assessed, are very common in young offenders. Chitsabesan et al. reported a study with incarcerated adolescents in England (93 boys

aged 15 to 18 years). Eighty-two percent reported a TBI and 18% had moderate-severe current post-concussion symptoms.(57) Those with Moderate to Severe TBI–(TBI) compared and No or Mild TBI (NoM TBI) - reported common comorbid issues: ADHD (29% of TBI: 20% of NoM TBI); speech and language impairments (TBI 36%: NoM TBI 41%); and alcohol (TBI 71%: NoM TBI 58%) and cannabis misuse problems (TBI 86%: NoM TBI 84%). However, the TBI group were significantly more likely to have previously been in care (64% vs 34%), and be at current risk of deliberate self-harm (57% vs. 43%) and suicidality (50% vs. 24%). A study by Vaughn and colleagues in the USA with "adjudicated adolescents" (n = 1345, aged on average 16, mostly (86%) male), also found that those with TBI had higher scores for a range of co-morbid issues - psychopathy, moral disengagement and impulsivity, bullying, peer delinquency, violent victimisation and witnessing violence.(58)

*Adult Populations:* A meta-analysis of lifetime prevalence of TBI in incarcerated adults versus general population indicate that it is significantly higher in the offenders.(59) The un-weighted pooled prevalence for TBI across 5049 subjects in 24 studies was 51.1%. Both males and females groups were affected. There also appears to be a "severity" effect. In a study in the USA, for example, on the lifetime prevalence of TBI in prisoners 65% of males and 72% of females reported one TBI with "alteration of consciousness".(60) Longer LOC was associated with more symptoms. In the UK, of 200 adult male prisoners, 60% reported a TBI of some form.(61) Moderate to severe TBI (LOC of 10 minutes or more) was reported by 16.6%. Those with a self-reported history of TBI were, on average, five years younger at the age of first prison sentence than uninjured (age 16 compared to 21) and had higher rates of reconviction. Schofield and colleagues, who examined 200 men in custody (aged 30), and 200 non- offenders (aged 43) in the community – from a matched (by residence) background - found that TBI was more common among prisoners (82% vs 72%).(62) There was also a higher proportion of prisoners with histories of LOC (65% vs 35%). Prisoners also had more multiple TBIs (42% vs 15%). Assault was the most common cause of injury in prisoners whilst 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 colleagues compared 139 male prisoners with 50 "no TBI" prison controls. (63) 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 (60.4% vs 38.0%). Fishbein and colleagues assessed executive functioning in 224 participants of a forensic rehabilitation programme.(64) Of these 28.3% (n = 71) reported head injury (3 minutes of LOC). Those with TBI had more problems in executive control and made less gains in treatment. Dys-executive disorders was linked to drop out from treatment and to less improvement on aggressive reactivity. They noted that 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 re-conviction. Shiroma and colleagues, in a US state-wide study over 11 years using linked hospital and justice data sets of 17,569 inmates, found that males and females with TBI had significantly higher rates of violent infractions.(65) Ray and Richardson conducted a longitudinal, prospective, follow up study of 151 inmates released from incarceration during a period of 12 to 30 months.(66) At 12 months post release 63% of those without TBI had not recidivated, whilst 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 socio-adversity factors. This is a particularly evident in studies with girls and women. Of 113 female prisoners in the USA, Brewer-Smyth et al. found that 42% had TBI histories, and those who had committed violent offences had suffered an average of two TBIs.(67) Domestic abuse, prior suicide attempts, and traumatic brain injuries with LOC, were all associated with current violent convictions. Similarly, Colantonio et al. found that females with TBI

who offend had suffered more early physical and sexual abuse than those without TBI.(68) Abuse, of various forms, could be associated with concussive blows and/or TBIs. Such injuries may complicate the experience of PTSD – with survivors having patchy recall of events.(69)

## Economic Costs

The Centre for Mental Health recently conducted an analysis of 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 age 15, 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

There are a range of measures that could reduce the risk of crime following TBI. First, any form of neuro-rehabilitation could offset the risk of violent crime.(70) Second, improved linkage between Emergency Departments, Community Mental Health Services (CAMHs), GPs and school systems might lead to early identification management of TBI in children and young people, particularly in lower socio-economic areas. This may reduce 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. Indeed, for young people in courts in UK there is now recognition that TBI should be taken into account in sentencing.(71) There are initiatives in England that allow screening for Neuro-disability in entrants into youth secure estate. There have also been pilot projects to assess for TBI and other NDs in

young adults and adult prisons.(63) (72) 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.(57) 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 where medication for attention deficit hyperactivity disorder in offenders led to a 30% reduction in criminality on release - possibly owing to improved impulse control. (73) In the UK Parliamentary bodies have noted the need to take account of TBI in the CJS. [INSERT BOXES 3 & 4].(74, 75)

## Research directions:

The causal mechanism that link TBI and crime are unclear. It may 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 also pre-TBI aggression is also a risk factor for post-TBI aggression.(76) Higher quality research is needed to explicate these links whilst accounting for the various factors that may 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/no" classification of presence or absence of TBI, and often there is no measure of injury severity. Furthermore measures of crime are often limited (e.g. 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. (57) Whilst, similarly, one study with adults found 70% agreement between self-reported and medically recorded TBI. (77) However, future research is needed with prospective, longitudinal, designs, with well validated and agreed TBI criteria. They should also have appropriate controls 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 neuro-trauma in offenders versus controls. Ideally there should be neuroimaging, such as Diffusion Tensor Imaging, alongside measurement of chronic TBI biomarkers such as Tau.(78) 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.(79)

Given the high levels of pre-injury developmental adversity, co-morbid neuro-disability, and mental ill-health in the populations studied, it is vital to establish how much of current functioning and behaviour is determined by TBI and/or these other factors.(80) Of particular importance is a need to explicate how TBI is situated within the criminogenic life histories of offenders. Crucially offenders often report childhoods characterised by harsh and/or inconsistent parenting and abuse- with angry and coercive role models for emotional regulation. (81) (82) Such environments could underlie an "adaptive" behavioural responses of hyper-vigilance for threat (83) (84, 85) and tendencies of being insensitive to others and impulsive.(55) There is evidence that adversity is associated with neurological anomalies in exposed young people compared to controls.(86) Furthermore, the lives of offenders, as illustrated by the levels of injuries sustained (e.g. in fights and road accidents) would suggest that there would be a role for current Post Traumatic Stress Disorder (PTSD) in some form in this population.(87) PTSD could contribute to problems with hypervigilance and impulsivity linked to criminality.(88) 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 enormous population of the CJS it would be important to determine what forms of screening could be done quickly and reliably (at arrest, court, prison, release, and probation), and how that data can be used to guide interventions. This should be tailored for particular regimes and within specific facilities (e.g. segregation, close supervision, or healthcare). 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 related to TBI. Furthermore, given that TBI appears to increase the

chances of violent crime, it is important that it is taken into account a factor for predicting future violence. Scalable tools such as OxRisk currently enable stratification of prisoners into high, medium and low risk groups.(89) Adding TBI as a factor in the model may increase predictive accuracy and enable enhanced support plans to reduce crime risk.

## Summary & Conclusions:

TBI appears linked to earlier age of incarceration, greater violence, and more convictions. Neurological abnormalities appear common in offenders. Brain functions, in areas important for social functions, such as impulse control and empathy, appear compromised. In those in custody, complicated Mild TBI and/or moderate to severe injury seems likely in 1-2 in 10, whilst another 3 or 4 in 10 may have milder form of TBI. Neuropsychological dysfunction is linked to violence, infractions in prison, poorer treatment gains and re-conviction. Life histories of abuse, neglect, and trauma appear particularly elevated in those with TBI versus control, 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 neuro-cognitive issues due to adverse life events. People with TBIs are incarcerated at high cost in facilities that may 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 whose “heads” were “pre-morbidly” set to be on a trajectory towards crime. Therefore even if they had a TBI it hardly mattered, whilst it, in fact, it did. Addressing TBI offers a means to not only improve the lives of those who offend, but also, crucially, reduce crime.

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**BOX 1: Search Strategy**
Ovid, Medline, Ovid-Psychinfo

Search Terms
"TBI" or "Head Injury"
Traumatic Brain Injury
Crime * [criminal]
Offend
Prison
Juvenile + Delinquent
From: April 15th 2007
Date: April 15th 2017

Articles identified 806. Of which relevant to TBI and Crime, 102.

**BOX 2: 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.(90)

A 2009 review reported that depression was increased after a TBI, but that the information for other psychiatric disorders was limited.(91)

Another review has reported rates of PTSD in 5-7% of individuals with mild TBIs. (92)

Since these reviews, high quality cohort studies have been conducted and found increased risk of new psychiatric disorders, including PTSD, panic disorder, social phobia, and agoraphobia, with 22% of individuals have new diagnoses. (93)

Other relevant research has been conducted in the US, where risk of incident psychiatric disorders was increased (relative risk of 2.8, 2.1-3.7)(94) but not for schizophrenia in Denmark.(95) A recent large population-based cohort study 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 (OR 2.6, 2.3-2.6) and suicide (OR 2.3, 1.9-2.9) compared with siblings who did not have diagnoses of any head injury.(96) A recent investigation of all individuals identified using healthcare registers who sustained head injuries until the age of 25 in Sweden found that risk of any inpatient psychiatric hospitalization (relative risk = 2.0, 1.9-2.0) and any psychiatric episode (relative risk = 1.5, 1.5-1.6) was higher than population controls. These risks were higher when head injury was sustained at older ages, and when it was more severe.(97)

## BOX 3: Justice Committee Report, UK Parliament

The Justice Committee of the Parliament of UK & NI 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 [often due to] traumatic brain injury". They add, how "Neurological impairments impact on [the] …capacity [of affected individuals] to desist from crime". They recommended a range of initiatives for prisons, including: screening, awareness training for staff; appropriate specialist support; data gathering for service deign and commissioning etc.

https://www.publications.parliament.uk/pa/cm201617/cmselect/cmjust/169/16905.htm#_idTextAnchor014

BOX 4: Review of Services for People with Brain Injury in Justice System commissioned by Justice Committee, Scottish Parliament

- A recent government report outlines a serviced pathway for people with brain injury in the criminal justice system in Scotland[1]
- 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-fold 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

http://www.nphn.scot.nhs.uk/wp-content/uploads/sites/9/2016/07/NPHN-Brain-Injury-and-Offending-Final-Report.pdf