Associations between significant head injury and persisting disability and violent crime in women in prison in Scotland, UK: a cross-sectional study

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Summary

Background The prevalence of head injury is estimated to be as high as 55% in women in prison and might be a risk factor for violent offending, but evidence is equivocal. The extent of persisting disability is unknown, making decisions about service needs difficult. The UN recognises vulnerabilities in women in prison, but does not include head injury. This study aimed to investigate relationships among head injury, comorbidities, disability, and offending in women in prison.

Methods In this cross-sectional study, women were recruited between Feb 2, 2018, and Sept 30, 2019, from four prisons across Scotland, UK: Her Majesty's Prison (HMP) Cornton Vale, Her Majesty's Young Offenders Institute Polmont, HMP Edinburgh, and HMP Greenock (detaining approximately 355 individuals at the time of recruitment). Women were included if they were aged older than 16 years, fluent in English, able to participate in face-to-face assessment and provide informed consent, and did not have a severe acute disorder of cognition or communication. Head injury, cognition, disability, mental health, and history of abuse and problematic substance use were assessed by interview. History of head injury was assessed with the Ohio State University Traumatic Brain Injury Identification method and disability was assessed with the Glasgow Outcome at Discharge Scale. Comparisons were made between women with and without a history of significant head injury.

Findings We recruited 109 (31%) of the 355 women in these prisons. The sample was demographically representative of the approximately 400 individuals in women's prisons in Scotland. Significant head injury (SHI) was found in 85 (78%) of 109 women, of whom 34 (40%) had associated disability. Repeat head injury was reported in 71 (84%) of the 85 women with SHI and, in most cases, this resulted from domestic abuse that had occurred over many years. Women with a history of SHI were significantly more likely to have a history of violent offences than those without a history of SHI (66 [79%] of 85 women in the SHI group *vs* 13 [54%] of 24 women in the no-SHI group had committed a violent offence; odds ratio [OR] 3·1, 95% CI 1·2–8·1). This effect remained significant after adjusting for current factors (3·1, 1·1–9·0), including comorbidities associated with post-traumatic stress disorder, and was no longer statistically significant after adjusting for historical factors (3·3, 1·0–10·9), such as abuse as a child or adult. Women with SHI had spent longer in prison than women without SHI after adjustment for current (rate ratio 3·4, 1·3–8·4) or historical (3·5, 1·3–9·2) risk factors.

Interpretation It is recognised that women in prison are vulnerable because of histories of abuse and problematic substance use; however, history of SHI needs to be included when developing criminal justice policy, interventions to reduce mental health morbidity, and assessment and management of risk of violent offending.

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Introduction

There is concern that the prison population has grown worldwide over the past two decades and that there has been a disproportionate increase in the number of women in prison.[1,2] Although women are less likely to become involved in the criminal justice system than are men, those who do are often highly vulnerable and present with complex mental health and psychosocial needs.[3] Studies in Europe and the USA have indicated clinically significant chronic health morbidity in women in prison, including mental health conditions and problematic substance use, which is more prevalent than in men in prison.[4–7] Furthermore, abuse as a child or adult is reported by most women in prison, and is linked to violent offending.[6]

Interest in head injury in people who are incarcerated and its relationship with crime has also grown.[8] Common persisting effects of head injury include impairments in information processing and executive function, and emotional changes associated with impulsivity, irritability, and egocentricity.[9] These cognitive and emotional effects can impair judgement and self-control and thereby increase risk of offending. The

Research in context

Evidence before this study

A systematic review by McGinley and McMillan published in 2019 suggested that there was a high prevalence of head injury and comorbidity among women in prison. To update this search, and to determine whether there was published evidence in women in prison with head injury on disability or consideration of comorbidities in analysis of violence, we searched PsycINFO (EBSCO), CINAHL (EBSCO), Embase (OVID), and MEDLINE (OVID) between Jan 1, 2019, and Feb 20, 2021, using the text word search used by McGinley and McMillan: (("Traumatic Brain Injury" OR TBI OR "Head Injur*")) AND ((crim* OR inmate* OR prison* OR offend*)). Only papers published in English were considered; full details of the search are provided in the appendix (p 1). Neither the systematic review by McGinley and McMillan nor any other study from our updated search indicated rates of disabling effects of head injury. Therefore, it was unclear whether a history of head injury is important and, if it is, in how many women. Some studies have shown an association between head injury and violent crime in women, but the evidence is equivocal. Several reviews point to the need for further research that considers comorbidity and uses representative samples.

Added value of this study

This study is the first to use multivariable regression to look at history of head injury and comorbidities, and outcomes of persisting disability and offending. It substantiates not only a high prevalence of significant head injury in a representative sample of women in prison across Scotland but also that disability is associated with such head injury in 40% of these offenders. Unlike the general population, head injury was most often caused by domestic abuse and was often repeated over periods of several years. After adjusting for multimorbidity, women with a history of significant head injury were three times more likely to have a history of violent offences than were women in prison without a history of such head injury.

Implications of all the available evidence

The UN has focused international concern over the growth in rates of incarceration of women, acknowledgment of the negative impact on family and social systems, and recognition of mental health vulnerabilities, and recommends the development of alternatives to custodial sentences and prevention of reoffending. However, head injury is not included as a vulnerability and evidence in this study indicates that it should be when developing policy in relation to progression through the criminal justice system, provision of rehabilitation and support, and reduction of recidivism. Given the high comorbidity between head injury and mental health problems, there is a need for head injury to be included as part of a holistic assessment and as an important feature in formulating interventions. The prevalence of significant head injury in the context of domestic abuse indicates a need for screening for head injury by workers in criminal justice, health care, and community settings.

effect on maturation of the developing brain is of concern, particularly given the suggested high occurrence of head injury in childhood in people who later commit offences.[8,10] Despite this association and the estimate that 55% of women in prison have a history of head injury with loss of consciousness,[11] systematic reviews consistently point to a paucity of evidence about women in prison with head injury.[12–15]

Although assumptions about causative links between cognitive and emotional effects of head injury and offending have high face validity, studies do not distinguish between individuals with persisting disabling effects and individuals with good recovery after head injury. No evidence on the occurrence of persisting disability after head injury in women in prison was found in the systematic review by McGinley and McMillan,[15] nor in our update of this search on Feb 20, 2021 (appendix p 1). It might be that, although a history of head injury is common in women in prison, persisting ill effects are not. Furthermore, women in prison often come from deprived backgrounds that are associated with chronic health morbidity,[4] which could independently cause cognitive impairment or disability. Hence, head injury might often cause disability in women in prison, be a key contributor to disability, or even have little persisting effect, with any disability arising from other causes. Given the international emphasis on improving health and reducing recidivism in women in prison,[1] there is a need to investigate the role of head injury in offending by establishing whether persisting disabling effects are probable in this population, taking other health problems into account. We aimed to investigate relationships among head injury, health comorbidities, disability, and offending in women in prison. We use the term offender in this study for clarity and in accordance with current usage in the criminal justice and forensic mental health systems, and it is not intended to be pejorative.

Methods

Participants

In this cross-sectional study, female offenders were recruited between Feb 2, 2018, and Sept 30, 2019, from four prisons across Scotland, UK: Her Majesty's Prison (HMP) Cornton Vale, Stirling; Her Majesty's Young Offenders Institute Polmont, Falkirk; HMP Edinburgh, Edinburgh; and HMP Greenock, Greenock. HMP Grampian, Peterhead, which comprises around an eighth of the female prison estate, was not included for logistical reasons owing to the distance of this site from the research base. Given the modest size of the female prison estate in Scotland, some women who had resided in HMP Grampian were incarcerated in the other

See Online for appendix

prisons, and there is movement between prisons after incarceration. Hence, some women who were initially placed in HMP Grampian were in the sample. The total number of women in Scottish prisons at the time of recruitment was around 400 and there were approximately 350 women in the prisons we recruited from.

To be included, women had to be in prison, aged older than 16 years, fluent in English, and able to participate in face-to-face assessment and provide informed consent. Women were excluded if they had a severe acute disorder of cognition or communication. If there was an acute disturbance affecting assessment (eg, due to problematic substance use), attempts were made to complete the assessment at a later date. Women were recruited through word of mouth, canteen sheets, and posters in prison halls. The project was advertised as a study on prisoner wellbeing to avoid bias towards recruiting women who believed they had a history of head injury or disabling head injury. Personal officers of the recruited women were also asked to participate. Each offender is allocated a personal officer for case management, who meets with them regularly and encourages engagement with them, such as rehabilitation or reintegration initiatives, and updates case records and reports.

Permission for the study was obtained from the West of Scotland National Health Service Research Ethics Committee (17/WS/0230) and from the Scottish Prison Service Research Ethics Committee. All participants provided written informed consent.

Procedures

In most cases, the assessment session with the offender lasted for approximately 90 mins. If they were fatigued or seemed unwell, by self-report or by observation of the assessor, the assessment was completed in a second session. To ascertain whether the sample was representative of the population of women in prison, demographic data were compared with those from a Scottish prison census.[16] Offenders completed a demographic and background questionnaire that included questions about schooling and school attendance, as well as history of drug and alcohol use. Deprivation quintiles were derived from postcodes with the Scottish Index of Multiple Deprivation,[17] a relative measure that ranks deprivation in Scotland across 6976 small areas and considers income, employment, education, health, access to services, crime, and housing. Head injury was assessed with the Ohio State University Traumatic Brain Injury Identification Method, a structured interview validated against a prison sample.[18] This method records information on cause and severity of head injury, including time periods when repeated head injury occurred within a short interval on two or more occasions (eg, domestic abuse). We refer to repeat or multiple head injury in this temporal context. Four cognitive tests assessed processing speed or learning (Symbol Digit Modalities Test),[19] auditory verbal list learning,[20] mental flexibility (Trail Making Test B),[21] and verbal fluency.[22] The Dysexecutive Questionnaire[23] was used to assess dysexecutive behaviour. Offenders completed the self-report version of this questionnaire and their personal officers completed the informant version. Delayed recall of the Word Memory Test assessed effort on cognitive tests, with a score below 34 indicating potentially poor effort.[24]

Disability was assessed with the Glasgow Outcome at Discharge Scale (GODS).[25] This scale is an assessment of disability for individuals in institutional settings and was developed from the Glasgow Outcome Scale, which was originally made for use in community settings. As in the Glasgow Outcome Scale, outcomes in the GODS are rated as good recovery, moderate disability, or severe disability. Disability on the GODS was rated as resulting from any cause (including head injury, or other physical or mental health causes) or from head injury specifically. This distinction arises from the structure of the rating form, which enquires about the presence of disability (any cause) and then whether head injury was the cause. The wording (but not the structure) was altered for a prison context by changing references to hospital staff or wards to prison staff or prison. The offender and their personal officer were interviewed separately with the GODS. The GODS uses information from an informant when available because head injury can result in impaired insight and individuals can be unaware of some of their limitations. The ratings on the GODS are judged by the assessor on the basis of all available evidence: the information from the informant is used to supplement that of the offenders, when given cogent examples by the prison officer.

The Hospital Anxiety and Depression Scale (HADS) assessed anxiety and depression, with scores above ten indicating moderate-to-severe abnormality.[26] The occurrence and frequency of lifetime traumatic events were assessed with the Traumatic Life Events Questionnaire.[27] Post-traumatic stress disorder (PTSD) was assessed with the PTSD checklist for DSM-5 (PCL-5), in which a score above 32 and fulfilment of criteria for intrusion, avoidance, and hypervigilance suggests PTSD.[28]

Definition of groups

Offenders were classified as having significant head injury (SHI) if they reported at least one single incident leading to mild head injury with loss of consciousness for less than 30 mins or moderate-to-severe head injury with loss of consciousness for at least 30 mins, or head injury without loss of consciousness on more than two occasions (SHI group). Offenders were classified as not having SHI if they reported no history of head injury or mild head injury without loss of consciousness on fewer than three occasions (no-SHI group).[29,30]

Outcome measures

Disability outcomes were defined as attributable to SHI or from any cause on the GODS. A composite score for cognitive function was calculated using Z scores for each

of the four tests, summed for each offender. The Z score represents deviation from the mean for the total sample for that test. Offending outcomes were type of offence (eg, violence, property, sexual, other), number of convictions, total time in prison, and longest sentence duration.

Statistical analysis

The aim of this study was to survey the entire population of women in prison in Scotland. Although we were unable to access HMP Grampian owing to geographical reasons, we were successful in accessing the three other prisons across Scotland that incarcerate women. Therefore, we did not carry out a formal sample size calculation because the intention was to recruit as many of the population as were willing and eligible to participate.

All statistical analyses were done in R (version 3.6.1). Variables are summarised as n (%), mean (SD), or median (IQR), as appropriate. Associations between offender characteristics and SHI were assessed for continuous variables with *t* tests (for those summarised as mean [SD]) or Mann-Whitney tests (for those summarised as median [IQR]), and with Fisher's exact test for categorical variables; all presented as p values. Cognitive test Z scores were adjusted for age, years of education, delayed Word Memory Test score, and methadone use in prison, and an overall Z score was calculated (appendix p 1).

Associations between head injury, comorbidities, and outcomes were assessed with regression models. Logistic regression model results are presented as odds ratios (ORs). The results from a quasi-Poisson model (allowing for overdispersion) for the integer outcomes (eg, number of convictions) are presented as rate ratios (RRs). Linear model results for overall cognitive impairment Z scores are presented as mean differences between women with and without SHI. Disability outcomes were modelled as binary variables, with disabled versus all other options (ie, good recovery, no SHI or disability, possible impairment).

All outcomes have two multivariable models fitted; one including current risk factors (eg, chronic physical health problem, presence of PTSD, clinical anxiety and clinical depression according to HADS), and a second including historical risk factors (eg, problematic alcohol or drug use, chronic physical health problem, any adult or childhood abuse). Model fit for the logistic regression models was assessed with the Hosmer-Lemeshow test. Linear models fitted to continuous outcomes were assessed visually from regression plots (appendix p 2).

We checked for multi-collinearity of the explanatory variables using Pearson correlation coefficients. The maximum bivariate correlation was 0·43, with the majority being under 0·20, which we deemed to be sufficiently low to include the variables in the models. We refitted the models with a random intercept for prison to assess clustering, but the fixed effects estimates were unchanged. Therefore, the models presented do not include random effects.

Because there were very little missing data in either the model outcomes or explanatory variables, models included only participants with available data for both.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

Of the 355 women incarcerated in the four prisons we recruited from, 109 (31%) expressed an interest in being part of the study and were seen by researchers, and all were deemed eligible to take part. Five of these individuals identified as transgender women. All but five individuals identified as ethnically White. The majority of the women were from the most deprived population quintile (table 1).[31] Although mean number of years of education was 12 years (SD 2), schooling was often disrupted by exclusion or truanting, and many women required special schooling or support. Before incarceration, 45 (42%) of 108 women (one individual missing data) were unemployed and 42 (39%) were unskilled workers. There was no significant difference between the SHI group (n=85) and no-SHI group (n=24) for age, ethnicity, deprivation, education, or school attendance (table 1).

Most (85 [78%]) of the 109 women reported a history of SHI. On the Ohio State University Traumatic Brain Injury Identification Method, the worst head injury was moderate-to-severe in 32 (30%) of 108 women (one individual missing data), of which four were severe (loss of consciousness >24 h). Overall, 71 (84%) of the 85 individuals with SHI reported one or more extended time periods in which repeat head injury occurred (ie, 66% of 108 women in the overall sample). Only five women had a single incident, moderate-to-severe head injury without multiple mild head injuries in addition. The SHI group (n=85) comprised 32 (38%) women with moderate-to-severe head injury, 34 (40%) with mild head injury and loss of consciousness, three (3%) with loss of consciousness of unclear duration (all had more than two head injuries), and 16 (19%) with more than two head injuries without loss of consciousness (all reported symptoms after head injury). The no-SHI group (n=24) comprised 16 (67%) women with no history of head injury and eight (33%) with fewer than three head injuries with no loss of consciousness, none of whom experienced a second head injury within a short time interval of the first. Of 84 women with SHI, a first head injury was reported before the age of 15 years in 58 (69%) and after age 15 years in 26 (31%). Two women reported a mild head injury in recent weeks and one reported a moderate head injury in recent months.

Among the 71 women with SHI and repeat head injury, domestic violence was the most common cause in 63 individuals (89%). The median duration of the first period of repeat head injury was 7 years (IQR 4–12;

	SHI group (n=85)	No-SHI group (n=24)	p value
Age, years	36 (8; 21–56)	37 (14; 20–73)	0·67
Ethnicity	..	..	0·51
White	80 (94%)	24 (100%)	..
Non-White*	5 (6%)	0	..
Scottish Index of Multiple Deprivation quintile†‡	..	..	0·80
5	1 (2%)	0	..
4	2 (3%)	1 (5%)	..
3	7 (11%)	2 (10%)	..
2	15 (25%)	3 (14%)	..
1	36 (59%)	15 (71%)	..
Years of education	11 (3; 0–20)§	12 (2; 10–16)	0·10
School type¶	..	..	0·42
Mainstream	35 (42%)	13 (54%)	..
Mainstream with 1:1 support	15 (18%)	2 (8%)	..
Specialist school	33 (40%)	9 (38%)	..
Missed school (truancy)	70 (85%)||	16 (70%)**	0·12
Missed school (suspension or exclusion)	51 (61%)¶	10 (43%)**	0·16
Most recent occupation§	..	..	0·10
Unemployed	36 (43%)	9 (38%)	..
Unskilled	34 (41%)	8 (33%)	..
Skilled	14 (16%)	5 (20%)	..
Professional or managerial	0	2 (8%)	..

Data are mean (SD; range) or n (%). SHI=significant head injury. *Ethnicity self-described as mixed (n=1), Asian (n=2), or Traveller (n=2). †Scottish Index of Multiple Deprivation in descending order of least deprived (5) to most deprived (1).[17] ‡Data available for 61 participants in the SHI group and 21 participants in the no-SHI group. §Data available for 84 participants in the SHI group. ¶Data available for 83 participants in the SHI group. ||Data available for 82 participants in the SHI group. **Data available for 23 participants in the no-SHI group.

Table 1: **Baseline characteristics**

range 0–29) and some women reported more than one such time period. Of the 71 women in the SHI group with repeat head injury, there was a history of more than one cause in 37 (52%), assault by another in 15 (21%), falls in 11 (15%), sport in 11 (15%), self-harm in three (4%), and a road traffic accident in one (1%). Causes among the 14 women without periods of repeat head injury were domestic violence in five (36%), other assault in five (36%), falls in three (21%), road traffic accidents in three (21%), and sport in two (14%).

A CNS diagnosis (other than head injury) in childhood (23 [23%] of 101) or in adulthood (34 [31%] of 108) was reported by 48 (46%) of 105 women with available data. A CNS diagnosis was almost twice as common in the SHI group (41 [51%] of 81) than in the no-SHI group (seven [29%] of 24), although this difference was not significant (p=0·10). Rates of these diagnoses in adulthood were similar between groups (27 [32%] of 84 in the SHI group *vs* 17 [29%] of 24 in the no-SHI group; p=1·00). In childhood, the rate of diagnosis was more than twice as high in the SHI group; again, this did not differ significantly (20 [26%] of 77 in the SHI group *vs* three [12%] of 24 in the no-SHI group; p=0·27). Most CNS diagnoses and exposure to lead occurred in less than 10% of women, except for cerebral anoxia (16 [15%]) or epilepsy occurring in adulthood (13 [12%]) in 107 individuals overall. None of the women reported a history of cerebral palsy, HIV or AIDS, or movement disorders (except for one with multiple sclerosis; appendix p 3).

Most (72 [67%]) of 107 women reported one or more physical health problems across a wide range of conditions, with no significant difference between groups (55 [66%] of 83 in the SHI group *vs* 17 [71%] of 24 in the no-SHI group; p=0·86). Respiratory problems (13 [12%]) and pain (nine [9%]) were most common in 105 women with available data. Multiple health problems were reported in similar proportions in the SHI group (16 [20%] of 81) and no-SHI group (five [21%] of 24; appendix p 4).

Almost all women complained of mental health difficulties (98 [92%] of 107), with significantly more in the SHI group (80 [96%] of 83) than in the no-SHI group (18 [75%] of 24; p=0·004; appendix p 4). Anxiety, depression, or the combination of both, were the most commonly self-reported mental health problems (50 [60%] of 83 in the SHI group *vs* 11 [48%] of 23 in the no-SHI group; p=0·34). Among 106 women, personality disorder was self-reported in 17 (16%), whereas psychosis (five [5%]) and other mental health conditions (four [4%]) were less common; all of these were reported as comorbid with other mental health conditions. HADS median scores were higher in the SHI group than in the no-SHI group for anxiety (14 [IQR 10–16] in the SHI group *vs* 11 [6–13] in the no-SHI group; p=0·003) and depression (10 [7–12] in the SHI group *vs* 7 [4–9] in the no-SHI group; p=0·012).

On the HADS, 73 (70%) of 105 women were above the moderate-to-severe cutoff (HADS >10) for anxiety and 37 (35%) for depression (appendix p 4). Although relatively large in magnitude, group differences were not significant with regard to the moderate-to-severe cutoff for anxiety (60 [74%] of 81 in the SHI group *vs* 13 [54%] of 24 in the no-SHI group; p=0·11) or depression (32 [40%] in the SHI group *vs* five (21%) in the no-SHI group; p=0·15).

Almost all women reported a history of abuse, which was repeated over time (table 2). Abuse was generally more common in the SHI group than in the no-SHI group, as was repeated abuse in adulthood or childhood. Sexual abuse in childhood or adulthood was common, as was physical abuse as a child or adult. PTSD was often present at the time of assessment and was about twice as common in the SHI group than in the no-SHI group (table 2).

A history of problematic alcohol or drug use was common, with a substantially higher occurrence of problematic use in the SHI group than in the no-SHI group (table 3). However, group differences were not explained by differences in age at first use.

Moderate or severe disability on the GODS that was specifically attributed to head injury was found in 34 (40%) of 84 women in the SHI group (table 4). Whether head injury was the cause of disability was uncertain in eight (10%) of these 84 women. Few individuals had severe disability associated with SHI (table 4).

In a multivariable logistic regression model, women with PTSD, a history of problematic alcohol or drug use, or a history of child abuse were more likely to have a disability attributed to SHI (*vs* good recovery, no disability, or possible impairment) than were women who did not have PTSD (OR 5·2, 95% CI 1·3–20·0), a history of problematic alcohol or drug use (9·1, 1·1–73·7), or a history of any child abuse (3·3, 1·1–9·9), although 95% CIs were wide. There was no evidence of an association between disability attributed to SHI and clinical anxiety or depression, a chronic physical health problem, or any adult abuse (appendix p 5).

A history of disability from any cause on the GODS was found in almost all women (103 [95%] of 108), and 87 (81%) women had a disability at the time of assessment. The occurrence of moderate disability was similar between groups, whereas severe disability was twice as common in the SHI group as in the no-SHI group (table 4).

SHI was associated with disability from any cause in a univariable model (OR 3·6, 95% CI 1·3–10·1); however, when current or historical risk factors were included as a multivariable model, the OR was reduced and the 95% CIs suggested no significant association (current 2·5, 0·6–9·5; historical 2·1, 0·5–9·0). A history of chronic physical health problems (4·9, 1·4–17·4), problematic alcohol or drug use (6·8, 1·1–40·6), or any child abuse (11·1, 2·9–42·0) showed strong associations with disability from any cause. Current PTSD (3·5, 0·9–14·2) and clinical anxiety (3·5, 0·9–12·8) had ORs of large magnitude but were not statistically significant for the associations with disability; CIs were wide in all cases owing to the small numbers of women without disability (appendix p 6). Four women with a disability from SHI did not also have a disability from any cause.

Cognitive test scores show little difference between both groups, as raw scores and after adjustment for age, years of education, delayed Word Memory Test score, and methadone prescription (appendix pp 7–9). Correspondingly, mean overall cognitive scores show little difference between groups (0·016 [SD 0·89] in the SHI group *vs* –0·054 [1·33] in the no-SHI group), with a difference in means of 0·02 (95% CI –0·48 to 0·51) adjusted for current risk factors and of 0·07 (–0·46 to 0·59) adjusted for historical risk factors. On the Word Memory Test, 90 (85%) of 106 women scored above the cutoff score of 33 at delayed recall, suggesting reasonable effort on cognitive tests. When women with Word Memory Test scores below 34 in the SHI group (n=10) and no-SHI group (n=6) were excluded, group differences for mean scores of overall cognitive impairment remained non-significant (0·04 [SD 0·92] in the SHI group *vs* 0·01 [1·10] in the no-SHI group; p=0·90).

A history of violent offences was common across all women, although more so in the SHI group than in the no-SHI group (table 5). Univariable analysis indicated that women with a history of violent offences were more likely to have a history of SHI than those without a history of such offences (OR 3·1, 95% CI 1·2–8·1). In multivariable analysis, SHI remained a risk factor for violence with no attenuation of risk when adjusting for current factors (3·1, 1·1–9·0) and was no longer significant after controlling for historical factors

	SHI group (n=85)	No-SHI group (n=24)	Total (n=109)	p value
Any childhood abuse	62 (76%)*	12 (50%)	74 (70%)	0·031
Sexual abuse	50 (61%)	9 (38%)	59 (56%)	0·061
Physical abuse	37 (45%)	4 (17%)	41 (39%)	0·016
Any adult abuse	72 (88%)*	18 (75%)	90 (85%)	0·22
Sexual abuse	40 (49%)	9 (38%)	49 (46%)	0·361
Physical abuse	70 (85%)	16 (67%)	86 (81%)	0·071
Any childhood or adult abuse	81 (99%)*	20 (83%)	101 (95%)	0·010
Repeated childhood abuse	50 (62%)†	8 (33%)	58 (55%)	0·026
Repeated adult abuse	66 (80%)*	11 (46%)	77 (73%)	0·002
Repeated childhood or adult abuse	76 (93%)*	15 (62%)	91 (86%)	0·001
Childhood abuse causing PTSD	59 (74%)‡	10 (42%)	69 (66%)	0·008
Adult abuse causing PTSD	69 (84%)*	16 (67%)	85 (80%)	0·11
Any childhood or adult abuse causing PTSD	78 (96%)†	19 (79%)	97 (92%)	0·019
PCL-5 score	49 (17; 8–77)*	34 (20; 1–70)	45 (19; 1–77)	0·001
Current PTSD§	63 (77%)*	9 (38%)	72 (68%)	0·001

Data are n (%) or mean (SD; range). SHI=significant head injury. PTSD=post-traumatic stress disorder. PCL-5=PTSD checklist for DSM-5. *Data available for 82 participants. †Data available for 81 participants. ‡Data available for 80 participants. §Defined as a PCL-5 score above 32 and fulfilment of criteria for intrusion, avoidance, and hypervigilance.

Table 2: **Differences in history of abuse and presence of PTSD between women in prison who had sustained a SHI and those who had not**

	SHI group (n=85)	No-SHI group (n=24)	Total (n=109)	p value
Problematic alcohol or drug use	77 (92%)*	13 (54%)	90 (83%)	<0·0001
Problematic alcohol use	52 (62%)*	6 (25%)	58 (54%)	0·003
Duration of alcohol problem, years	10 (2–17; 0–28)†	2 (2–3; 1–10)	8 (2–13; 0–28)	0·107
Age at first use, years	16 (14–26; 10–34)‡	18 (17–20; 15–26)	17 (14–25; 10–34)	0·56
Problematic drug use	70 (83%)*	13 (54%)	83 (77%)	0·007
Duration of drug problem, years	14 (12–20; 1–36)§	10 (5–15; 2–27)	14 (10–19; 1–36)	0·084
Age at first use, years¶	16 (13–20; 10–46)	16 (14–18; 13–23)	16 (13–19; 10–46)	0·70

Data are n (%) or median (IQR; range). SHI=significant head injury. *Data available for 84 participants. †Data available for 46 of 52 participants with problematic alcohol use. ‡Data available for 47 of 52 participants with problematic alcohol use. §Data available for 63 of 70 participants with problematic drug use. ¶Data available for 64 of 70 participants in the SHI group and 12 of 13 participants in the no-SHI group with problematic drug use.

Table 3: **Differences in history of alcohol and drug use between women in prison who had sustained a SHI and those who had not**

	SHI group (n=84)	No-SHI group (n=24)	Total (n=108)
Disability from any cause			
Good recovery	12 (14%)	4 (17%)	16 (15%)
Moderate disability	36 (43%)	10 (42%)	46 (42%)
Severe disability	36 (43%)	5 (21%)	41 (38%)
No disability history	0 (0%)	5 (21%)	5 (5%)
Disability from SHI			
Good recovery	42 (50%)	..	42 (50%)
Moderate disability	31 (37%)	..	31 (37%)
Severe disability	3 (4%)	..	3 (4%)
Unclear if head injury cause	8 (10%)	..	8 (10%)

Data are n (%). SHI=significant head injury.

Table 4: **Disability on the Glasgow Outcome at Discharge Scale in women in prison, according to whether they had previously sustained a SHI**

	SHI group (n=85)	No-SHI group (n=24)	Total (n=109)
Violent offences	66 (79%)*	13 (54%)	79 (73%)
Sexual offences	3 (4%)*	0 (0%)	3 (3%)
Property offences	45 (54%)*	12 (50%)	57 (53%)
Other offences	64 (76%)*	18 (75%)	82 (76%)
Age at first arrest, years	17 (14–25; 9–54)†	19 (16–35; 8–69)‡	17 (14–25; 8–69)
Number of convictions	6 (1–10; 1–100)§	2 (1–14; 0–40)‡	4 (1–11; 0–100)
Cumulative prison time, months	12 (3–54; 0–252)¶	4 (2–14; 0–60)‡	10 (3–40; 0–252)
Longest length of sentence, months	26 (11–138; 0–330)||	22 (12–48; 0–276)‡	24 (11–84; 0–330)

Data are n (%) or median (IQR; range). SHI=significant head injury. *Data available for 84 participants. †Data available for 77 participants. ‡Data available for 23 participants. §Data available for 82 participants. ¶Data available for 79 participants. ||Data available for 73 participants.

Table 5: **History of offending in women in prison, according to whether they had sustained a SHI**

(3·3, 1·0–10·9). There was no evidence of an association between the other health factors and violent offending, with the exception of adult abuse, which was strongly associated with violent offending (6·3, 1·9–21·0), albeit with a wide 95% CI. There was no evidence of group differences for property-related (1·2, 0·5–2·9) or other offences (1·1, 0·4–3·1) and only three individuals had committed sexual offences (appendix p 10).

Women with SHI had spent more than three times longer in prison (RR 3·4, 95% CI 1·3–8·4 adjusted for current risk factors and 3·5, 1·3–9·2 adjusted for historical risk factors) than women with no SHI (appendix p 11). Similarly, women with chronic physical health problems had spent more than two and a half times longer in prison than women without (2·6, 1·3–5·5; appendix p 11). There was no evidence of an association between number of convictions and SHI (1·4, 0·6–3·5 adjusted for current risk factors and 1·1, 0·5–2·4 adjusted for historical risk factors) or with the other health factors (appendix p 12). Although age at first arrest had a univariable association with SHI, this became non-significant after adjustment for current (adjusted difference –5·2 years, 95% CI –10·8 to 0·3) or historical variables (–1·5 years, –6·8 to 3·8; appendix p 13). Similarly, there was no evidence of an association between SHI and longest length of prison sentence (unadjusted OR 1·6, 0·8–3·1; appendix p 14).

Discussion

In this cross-sectional study on head injury in 109 women incarcerated in four Scottish prisons, associated disability was common but was not found in all cases. There was a strong relationship between a history of SHI and violent crime. High multimorbidity in women with SHI, particularly a history of abuse and problematic substance use, and current PTSD, was found. These findings have implications for policy and interventions for women in prison, including offender treatment programmes and risk management.

The sample was demographically representative of women in prison in Scotland. All but five women identified as ethnically White, which is consistent with the ethnic breakdown of Scottish prisons[31] and of the general population of Scotland (in which 4% of individuals identify with an ethnicity other than White). In the Scottish prison population census, age (35 years [SD 10]) and social deprivation (55% most deprived and 3% least deprived quintiles) of women in prison[16,31] were similar to the study sample (table 1).

Women in prison with SHI differ from women in the general population with SHI. Domestic violence was the most common cause of SHI in women in prison, whereas falls are most common in the general population.[32] Furthermore, head injury occurred repeatedly in around two-thirds of women in prison, whereas a single incident head injury resulting from an accident is typical in the general population.[32,33]

The self-reported prevalence of SHI was very high in women in prison (85 [78%] of 109 women), as reported previously.[15] However, most women reported mild head injuries, two-thirds of which were repeated over long periods of time, often lasting several years. A history of head injury of this kind invokes considerable risk of cumulative brain damage, particularly when the injuries occur in close temporal proximity without opportunity for recovery between events.[18,34] The high proportion of women with persisting disability associated with SHI (40% with a further 10% possibly disabled by SHI) supports this risk. On the basis of our representative sample, we estimate that around 30–40% of all women in prison in Scotland are disabled by head injury. Although it might seem surprising that poorer cognitive function was not found in the SHI group compared with the no-SHI group, this finding might be explained by multimorbidity in the overall sample, who underperformed on cognitive tests relative to norms (appendix p 15).

SHI was associated with violent crime but not other crimes, and this finding is consistent with predicted behavioural effects of reduced emotional control and impulsive aggression after SHI.[9] Consideration of comorbidities (including history of abuse when investigating

relationships between violent crime and head injury) has been emphasised,[35] and our investigation shows that SHI remains a significant risk factor for violent offending after adjusting for current health factors. Together with the finding that women in prison with SHI had spent three times longer in prison than those without SHI, the association with violent offending indicates a need for SHI to be taken into account in rehabilitation programmes in the criminal justice system.[36] In part, this step might involve educating offenders about the effects of head knocks on emotional control and behaviour. In our sample, women often did not know that so-called head knocks could cause brain injury; given the strong association between domestic abuse and head injury in these women, education should include understanding that repeat head injury can cause cumulative brain damage.[34] Some individuals might not attend hospital after head injury,[16,37] and because this is particularly likely to be the case for those subjected to domestic violence,[38] it emphasises the need for education.

It is well known that women in prison often have complex health problems,[1,4] and difficulties with mental health and problematic substance use are common in female offenders with head injury.[13,39] Almost 95% of our total sample reported health difficulties, with reduced daily function in most of these women. Women with SHI were at higher risk of having a history of mental health problems, abuse, and problematic substance use, and of currently having PTSD and more severe anxiety and depression symptoms than those with no SHI. Notably, few women reported SHI as their only health issue, and it is striking that the risk of persisting disability due to SHI was around five times higher in women with PTSD than in those without. However, this finding is not surprising given that SHI is often caused by domestic violence or other abuse. This complexity is likely to arise in childhood for some women in prison, in whom the high incidence of special educational needs and disruption in schooling, and the occurrence of SHI before the age of 16 years in about two-thirds of our sample, suggests a risk of neurodevelopmental disorder. The legacy of a history of deprivation, abuse, and brain injury in childhood might include domestic violence, problematic substance use, and, more broadly, disability and behaviours resulting in rule breaking and offending through adolescence and into adulthood. Hence, there is a need to recognise these vulnerabilities at an early stage, including first contact with the criminal justice system, to assess the individuals and provide long-term support.[40]

Our findings have important implications for assessment, triage, and intervention. Assessment needs to be holistic, given the prevalent multimorbidity, consider the overlap in symptoms between common comorbidities (eg, PTSD, anxiety, depression), assess disability, and consider its probable cause. The high prevalence of disability associated with SHI indicates that routine screening is needed throughout the criminal justice system with triage to education, intervention, and support.[36] It is well recognised that there is a general need to develop mental health services for women in prison.[5,12] A holistic perspective to formulation and intervention that addresses SHI is necessary in prison mental health services, given its association with disability and violence. Notably, women in this study anecdotally reported receiving no specialist support for trauma in prison, despite the very high prevalence of PTSD (data not shown). Additionally, it is well known that offenders often have a history of being subjected to domestic violence,[41] and there have been calls for routine screening for interpersonal violence and head injury in all health-care settings.[42] The high risk of consequent disability deserves widespread attention, including in criminal justice and non-health-care community settings. Workers with women subjected to abuse should be trained to screen for SHI and include it in formulation for intervention and support. Future research in prisons and the community on interventions aimed at improving health and reducing recidivism through this holistic perspective is needed.

The high prevalence of several conditions, such as head injury, chronic physical conditions, adult trauma, and problematic substance use, contributed to multivariable models estimating some effects with low precision and correspondingly wide 95% CIs. Nevertheless, the point estimates were in accordance with the descriptive statistics and are consistent across models. This finding indicates that, although the magnitude of differences between women with and without SHI might not have been estimated precisely, it was substantively robust. Data were largely obtained from self-report, which is a limitation, given the potential for error in recall. We did adopt techniques to minimise this potential source of error (appendix p 16). Furthermore, in relation to assessment of head injury, it is of note that offenders do not always attend hospital when injured[37] and that medical records might not reflect the high frequency of repeated, mild injuries found in this study; therefore, self-report is necessary.

The UN recommends development of alternatives to custodial sentences for women and prevention of reoffending. These recommendations stem from recognition that offenders are vulnerable because of mental health needs arising from histories of abuse, PTSD, and substance dependency; poorer access to health services in custodial settings than in the community; and damage to families resulting from disruption of maternal roles if incarcerated.[1] This study indicates a need for a history of SHI to be added to this list of vulnerabilities, given the high prevalence of occurrence with associated disability and relationship with violent offending in women in prison. SHI needs to be included in policies for violence risk management, mental health, prisoner support, and rehabilitation, and for progression through the criminal justice system, including from higher to lower security estates.

Contributors

TMM conceptualised the study design and methodology; did the literature search; supervised the project; contributed to validation, curation, analysis, and interpretation of the data; wrote the original draft; and reviewed, edited, and finalised the manuscript. HA contributed to project administration, investigation, and recruitment; data acquisition, curation, validation, and visualisation; and writing, reviewing, and editing. EC and ES contributed to study design, administration, investigation, and recruitment; data acquisition, curation, and validation; and writing, reviewing, and editing manuscript drafts. SJEB contributed to data curation, software, formal analysis, data interpretation, visualisation, writing, reviewing, and editing. The database for the study has been accessed and verified by TMM, HA, and SJEB. All authors had full access to all the data in the study and had final responsibility to submit for the decision to submit for publication.

Declaration of interests

We declare no competing interests.

Data sharing

No data are available for sharing.

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