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## LAW, CRIMINOLOGY & CRIMINAL JUSTICE | RESEARCH ARTICLE

# Traumatic brain injury among young offenders in France based on the results of the Fleury TBI study

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**Abstract:** *Objective:* This study aimed to estimate the prevalence of traumatic brain injury (TBI) in a French prison population of young offenders and to study variables known to be associated with TBI. It also aimed to study whether TBI was associated with younger age at entry into prison; longer period of custody and re-offending. *Participants:* All young offenders (from 13 to 21) consecutively admitted to Fleury-Mérogis prison over a period of 3 months were included. *Method:* During the admission procedure, young offenders were interviewed by healthcare staff using a self-reported questionnaire. Comparisons between cases (TBI +) and controls (TBI –) were performed. *Results:* Three hundred thirty two young offenders were included. The prevalence of self-reported TBI was 24.5%. The first cause of TBI was violence-related outcomes (25%). No differences were found regarding the number of times in custody and the total time spent in prison during the preceding five years. Cases accumulated multiple health problems including mental health problems (16.3% vs. 4.9%;  $p = .002$ ) and a regular use of cannabis (28.7% vs. 15.9%;  $p = .02$ ). *Conclusions:* The results provide further evidence that specific measures need to be developed such as, first of all, screening for TBI and related impairments upon arrival in prison.

**Subjects:** Forensic Science - Law; Social Sciences; Behavioral Sciences; Population Health; Behavioral Medicine

**Keywords:** outcome; traumatic brain injury; violence; young offenders; prison

### ABOUT THE AUTHOR

Eric Durand (MD PhD) specialized in Physical Medicine and Rehabilitation (MPR) at La Pitié-Salpêtrière hospital in Paris, especially in Neurorehabilitation which deals, among other things, with the care and follow-up of patients who sustained a stroke or a traumatic brain injury. Among disorders which are described after a brain injury, cognitive and behavioral sequelae constitute a major obstacle to the social, family and professional rehabilitation of these patients. For many years now, he has been interested in the association between these particular disorders and criminality. He recently performed a study on the prevalence of self-reported traumatic brain injury among 1148 prisoners in France. His last paper, published in this issue of *Cogent Social Sciences*, is related to young offenders and traumatic brain injury. It is part of a larger project studying violence related behaviors after a brain injury.

### PUBLIC INTEREST STATEMENT

The aim of this study was to estimate the number of young offenders who reported a Traumatic brain injury (TBI) in a French prison. The study also focused on other medical variables known to be associated with TBI. A group of 332 young offenders consecutively admitted to Fleury-Mérogis prison (France) over a period of 3 months were included. During the admission procedure, young offenders were interviewed by healthcare staff using a self-reported questionnaire. Nearly 25% of the interviewed young offenders reported a TBI. The first cause of TBI was violence-related outcomes. Cases (TBI +) accumulated multiple health problems including mental health problems and use of cannabis. The results provide further evidence that specific measures need to be developed such as, first of all, screening for TBI and related impairments upon arrival in prison.

## 1. Introduction

Traumatic Brain Injury (TBI) which is one of the major causes of death and disability among children and working age adults (Fleminger & Ponsford, 2005) continues to be a serious public health concern (Centers for Disease Control and Prevention [CDC], 2003; Langlois, Rutland-Brown, & Wald, 2006; Thurman, Alverson, Dunn, Guerrero, & Sniezek, 1999). According to some studies, the prevalence of TBI of all severities among the population as a whole would be 8.5% (Silver, Kramer, Greenwald, & Weissman, 2001). In a more recent study, performed in Colorado, the distribution of self-reported lifetime injury was 36.4% for mild TBI and 6.0% for moderate-severe TBI (Whiteneck, Cuthbert, Corrigan, & Bogner, 2016).

A TBI is caused by a bump, blow, or jolt to the head or a penetrating head injury that disrupts the normal function of the brain (CDC, 2003). TBI can result in lifelong cognitive, behavioral and emotional consequences (Jourdan et al., 2016; Langlois et al., 2006). Cognitive deficits are often dominated by executive, attention and memory dysfunction in adults (Jourdan et al., 2016; Mazaux et al., 1997). Behavioral disorders may cause social integration difficulties and may sometimes be associated with mood disorders (Baguley, Cooper, & Felmingham, 2006; Cattalani, Roberti, & Lombardi, 2008). Authors studying executive functions after TBI in children report disorders of the basic processes of working memory and inhibition, and impairments of more complex processes such as decision-making. Other domains such as motivation, self-regulation and social cognition can also be affected (Levin & Hanten, 2005 for a review).

Moreover, there is increasing evidence that there is a strong association between TBI and criminal offending (Elbogen, Wolfe, Cueva, Sullivan, & Johnson, 2015; Fazel, Lichtenstein, Grann, & Långström, 2011; Timonen et al., 2002). Recent research also estimates the prevalence of TBI among offenders to be between 40 and 60% (Durand et al., 2017; Farrer & Hedges, 2011; Shiroma, Ferguson, & Pickelsimer, 2010). However, in another recent review about the prevalence of TBI among offenders, authors pointed out that the high degree of variation in TBI rates may be attributed to the inconsistent way in which TBI was measured (O'Rourke, Linden, Lohan, & Bates-Gaston, 2016).

In Timonen et al.'s study, a history of TBI in childhood or adolescence increased the risk of psychiatric disorders in adulthood. Among males, a history of TBI was significantly associated with subsequent psychiatric disorders and criminality. Criminals who sustained a TBI before the age of 12, started their "criminal career" significantly earlier compared with subjects who had a TBI after the age of 12 (Timonen et al., 2002). In another study, using meta-analytic techniques to examine the odds of having had a TBI among juvenile offenders, a calculated summary odds ratio of 3.37 suggested that juvenile offenders were significantly more likely to have sustained a TBI compared to controls (Farrer, Frost, & Hedges, 2013). Among young offenders, the last review highlighted that reported prevalence rates of TBI range from 16.5 to 72.1% (Hughes et al., 2015).

In Sweden, a longitudinal population-based study found that, after adjustment for familial confounding factors, there was a significantly increased risk of violent crime in individuals with a history of TBI (Fazel et al., 2011). More recently, a study found that post-TBI criminal arrest was associated with male gender, age below 25, absence of marital status, lower educational attainment, pre-TBI felony, pre-TBI drug abuse, pre-TBI alcohol abuse, and violent cause of TBI (Elbogen et al., 2015). Finally, a survey performed in Australia indicated that there is a modest causal link between TBI and criminality after comprehensive adjustment for confounding factors and that reducing the rate of TBI, a major public health imperative, might have benefits in terms of crime reduction (Schofield et al., 2015).

In the field of criminal justice, it is recognized that the personalities of juveniles are still developing and open to positive influences. Emphasis must be placed on the possibility of re-integrating young offenders with the major aim of preventing reoffending, especially when they suffered from a brain injury during childhood ... (Price, Daffner, Stowe, & Mesulam, 1990).

In many countries, “young offenders” include people aged from 13/14 to 21 because they usually have the same kind of behavioral issues and disciplinary problems in custody. In this article the term “young offenders” refers to prisoners aged 13 to 21 years. In France, the minimum age for imprisonment is 13.

Two previous paper, related to the results of the Fleury TBI study, estimated the prevalence of self-reported TBI in a representative population of 1,079 prisoners, aged from 18 to 75 (mean 28.6), to be 32% among males and 22.7% among females in France (Durand et al., 2016a, 2016b). The primary aim of this study, based on the results of the Fleury TBI study, was to estimate the prevalence of self-reported TBI in a population of young prisoners in a French prison. Secondary aims included studying co-variables that are known to be positively associated with TBI such as mental health problems, use of alcohol and/or cannabis and psychoactive treatments, and comparing those co-variables across prisoners with and without a history of TBI. They also included studying whether TBI was associated with younger age at entry into prison; longer period of custody and re-offending.

## 2. Methods

The setting and material used have been described elsewhere (Durand et al., 2016a, 2016b). To summarise, we performed a cross sectional study, during a three month period, using a questionnaire (see below) between November 2012 and January 2013. This study was conducted at Fleury-Mérogis Prison which is located in the southern suburbs of Paris and which is designed to take 2,855 prisoners. This prison comprises a men’s jail, a women’s jail (for adults and female juveniles) and a jail for male juveniles.

### 2.1. Population

All young offenders (males and females), aged 13 to 21 years, consecutively admitted during a three months period were included in the study. During the routine admission procedure they were interviewed by health care staff (nurses and doctors) who had been trained earlier as to the aims of the study and the completion of a self-reported anonymous questionnaire. Ethical approval for this study was provided by the Paris VI University (Pierre and Marie Curie University) and by the Consultative Committee for Treatment of Health Research Information, which stated that written consent was not needed. Information about the study was given by a prison nurse or a prison doctor, and informed consent for participation was given orally. Prisoners could refuse to participate without there being any consequences. Whenever possible, the reason for an interview refusal, or non-completion, was recorded.

### 2.2. Material

The questionnaire was administered during the systematic semi-structured interview performed on admission to the prison. It included demographic information and education level. It also included information about perceived health, history of TBI and epilepsy, any psychiatric and neurological follow-up, questions about the use (daily, regularly ...) of alcohol, cannabis or other psychoactive drugs. Information about offending history was also recorded: number of previous imprisonments (in addition to the present one), total length of custody in the last five years, remand or convicted status. In France, remand prisoners are awaiting trial, which means they have been accused of a crime but have not yet been proven guilty.

The first question about the incomer’s history of TBI was translated from a questionnaire created by Williams et al. (2010b): “Have you ever had an injury to the head that caused you to be knocked out and/or dazed and confused e.g. from a fall, blow to the head (including boxing or fighting) or road accident?” Whenever a TBI was reported, related information about the TBI was recorded: circumstance, age at first and last TBI (when appropriate), loss of consciousness (LOC), hospitalisation, coma ... As it was a declarative study, the Glasgow coma scale could not be used and participants were asked “if they had been in a coma as a result of their TBI”. When the answer was “yes” a coma was recorded. TBI was considered as severe if there was a self-reported coma, and as moderate if there was a self-reported hospitalisation without a coma. All the other self-reported TBI were considered as mild TBI. Prisoners were also asked if they had benefitted from any specialized follow-up after their TBI.

### 2.3. Statistical analyses

The study population was described, distinguishing between male and female young offenders. Medical history, drug and alcohol use were studied, as well as characteristics of self-reported TBI. For alcohol use, two binary variables were defined: “Alcohol use” when offenders declared alcohol use during the last 30 days, as opposed to no use during the last 30 days and “regular alcohol use” when offenders declared regular or daily alcohol use during the last 30 days, as opposed to no use or occasional use during the last 30 days. The same binary variables were defined for cannabis. Due to sample sizes, daily use could not be considered separately. Frequency distribution (%), mean and standard deviation (SD) were computed according to qualitative and continuous variables. Regarding the non-negligible number of missing data for some variables, percentages included missing value frequencies.

Comparisons between young offenders who reported one or several TBI (cases) and those who did not (controls) were also carried out. *P* were calculated with the t-test or non-parametric Wilcoxon signed-rank test for continuous variables and  $\chi^2$  test for the others. Analyses were performed using SAS version 9.3.

## 3. Results

### 3.1. Description of the prisoner population

A total of 332 young offenders (302 males and 30 females) were admitted during the study period (Table 1). Among them, 69 were juveniles (20.7%). Overall, 332 questionnaires were answered but in 6 cases the information regarding history of TBI was missing. In this population, current age was

**Table 1. Characteristics\* of the study population according to gender (N = 332)**

Characteristics	Age < 22 years	
	Females (n = 30)	Males (n = 302)
Age, mean (SD), yrs	17.8 (2.30)	18.9 (1.69)
>10 yrs education, n (%)	5 (16.7)	135 (44.7)
Occupation <sup>1</sup> , n (%)	0	64 (21.2)
Worker	0	21 (7.0)
Employee	0	0
Executive	4 (13.3)	23 (7.6)
Unknown	6 (20.0)	103 (34.1)
Unemployment		
Convict status <sup>2</sup> , n (%)	14 (46.7)	128 (42.4)
Age at 1st imprisonment <sup>3</sup>	17.4 (2.27)	18.2 (1.83)
Mean (SD), yrs		
Number of previous imprisonments <sup>4</sup>	1.2 (.42)	1.6 (1.25)
Mean (SD)		
Total time in jail during the past 5 yrs <sup>5</sup>	6.1 (7.38)	7.0 (4.60)
Mean (SD), months		

\*Descriptive statistics were computed considering missing values. A note indicates when >15% of the data in a group were missing values.

<sup>1</sup>>66% of missing data for females and >30% for males.

<sup>2</sup>>30% of missing data for females and >18% for males

<sup>3</sup>>16% of missing data for females.

<sup>4</sup>>36% of missing data for females.

<sup>5</sup>>76% of missing data for females and >18% for males.

Yrs: years.

17.8 years for females and 18.9 for males. Education level was low with 58% having less than 10 years of education.

They had their first contact with the custodial system between 17 and 18 (mean 17.4 years for females and 18.2 for males). They came to prison more than once (mean 1.2 for females and 1.6 for males) and had spent a few months (mean between 6 and 7 months) in prison over the past 5 years. More than half were remand prisoners.

### 3.2. Medical and recreational drug use history

Prevalence of self-reported epilepsy was 4% for males ( $n = 12$ ) and 0% for females. Psychiatric care was reported by 8% of young male offenders and 3.3% of young female offenders. Thirteen offenders reported an anxiolytic treatment and nine an antidepressant treatment. Young offenders reported the use of alcohol in 100/332 cases and the use of cannabis in 112/332 cases. Regular or daily alcohol and cannabis use was found in 28/332 cases and 63/332 cases respectively.

### 3.3. Description of the TBI population

The prevalence of a self-reported history of TBI was 25.8% for male young offenders ( $n = 78$ ) and two juvenile females among 30 declared a history of TBI (Table 2). Violence related injuries (20/80), Road traffic accidents—RTA—(18/80), and falls (8/80) were the major causes of TBI (Table 3). The majority of TBIs were sustained during adolescence (44/80 occurred between 13 and 21). The first TBI had been sustained between 0 and 6 in 16/80 cases and between 7 and 12 in the same number of cases.

Out of 80 young offenders who reported a history of TBI, 39 reported a LOC (less than 24 h), nine a coma and 23 a hospitalisation. According to the definition used, nine offenders sustained a severe TBI, 14 a moderate TBI and 39 a mild TBI. They reported more than one TBI in 28/80 cases. A large majority of the population with a history of TBI had no subsequent follow-up related to their TBI (66/80). The first TBI occurred before the first imprisonment in most cases (73/80; 92.3%).

### 3.4. Comparisons between cases and controls (Tables 4 and 5)

Cases and controls did not differ in terms of age ( $p = .19$ ). Both groups had had their first contact with the prison around 18 ( $p = .96$ ). No difference was found regarding the number of times in custody or the total time spent in prison during the preceding five years ( $p = .11$  and  $p = .16$ ).

**Table 2. Medical history, drug and alcohol consumptions\* of the study population according to gender (N = 332)**

	Age < 22 years	
	Females (n = 30)	Males (n = 302)
	n (%)	n (%)
History of TBI <sup>1</sup>	2 (6.7)	78 (25.8)
Epilepsy	0	12 (4.0)
Psychiatric care	1 (3.3)	24 (8.0)
Anxiolytic treatment	2 (6.7)	11 (3.6)
Antidepressant treatment <sup>2</sup>	1 (3.3)	8 (2.7)
Alcohol use	1 (3.3)	99 (32.8)
Regular alcohol use	-	28 (9.3)
Cannabis use <sup>3</sup>	3 (10.0)	109 (36.1)
Regular cannabis use <sup>3</sup>	1 (3.3)	62 (20.5)

\*Descriptive statistics were computed considering missing values. A note indicates when >15% of the data in a group were missing values.

<sup>1</sup>Traumatic Brain Injury.

<sup>2</sup>>16% of missing data for females.

<sup>3</sup>30% of missing data for females.

**Table 3. Description\* of reported traumatic brain injury in the study population according to gender (N = 80)**

	Age < 22 years	
	Female (n = 2)	Male (n = 78)
	n	n (%)
<i>Causes</i>		
Road traffic accident	1	17 (21.8)
Sport accident	-	6 (7.7)
Fall	-	8 (10.3)
Violence related	1	19 (24.4)
Combination of causes	-	6 (7.7)
Other	-	12 (15.4)
Follow-up after TBI <sup>1</sup>	1	13 (16.7)
LOC <sup>2</sup>	2	37 (47.4)
Coma	0	9 (11.5)
Hospitalization for TBI <sup>1</sup>	1	22 (28.2)
More than one TBI <sup>1</sup>	1	27 (34.6)

\*Due to small samples percentages were not computed for females, for males, they were computed considering missing values. A note indicates when >15% of the data in a group were missing values.

<sup>1</sup>Traumatic Brain Injury.

<sup>2</sup>Loss of consciousness excluding coma.

**Table 4. Demographic and penitentiary characteristics according to traumatic brain injury—N = 326**

	Presence of TBI <sup>1</sup>	Absence of TBI <sup>1</sup>	P <sup>2</sup>
	(n = 80)	(n = 246)	
Age, mean (SD), yrs	19.0 (1.74)	18.7 (1.79)	.19
>10 yrs education, n (%)	37 (46.3)	102 (41.5)	.42
Occupation <sup>3</sup> , n (%)			.78
Worker	20 (25.0)	44 (17.9)	
Employee	6 (7.5)	14 (5.7)	
Executive	-	-	
Unknown	6 (7.5)	21 (8.5)	
Unemployment	27 (33.8)	78 (31.7)	
Age at 1st imprisonment	18.1 (1.92)	18.1 (1.87)	.96
Mean (SD), yrs			
Number of previous imprisonments	1.7 (1.51)	1.4 (1.08)	.11
Mean (SD)			
Total time in jail during the past 5 yrs <sup>4</sup>	7.4 (7.41)	6.6 (7.01)	.16
Mean (SD), months			
Convict status <sup>5</sup> , n (%)	31 (38.8)	108 (43.9)	.26

<sup>1</sup>Traumatic Brain Injury.

<sup>2</sup>P were calculated with the t-test or non-parametric Wilcoxon signed-rank test for continuous variables and chi-square test for the others.

<sup>3</sup>34% of missing data.

<sup>4</sup>when number of additional imprisonments was known, missing data of “Total time in jail during the past 5 yrs” variable have been replaced. Using the 247 known responses, an average total time in jail during the past 5 years was estimated for each number of additional imprisonments. Those averages were used to replace 37 of 79 missing values.

<sup>5</sup>19% of missing data.

Yrs: years.

**Table 5. Medical history, drug and alcohol consumptions in relation to traumatic brain injury - N = 326.**

	Presence of TBI <sup>1</sup>	Absence of TBI <sup>1</sup>	P <sup>2</sup>
	(n = 80)	(n = 246)	
	n (%)	n (%)	
Perceived health			.0009
Very bad/Bad	7 (8.8)	3 (1.2)	
Average	13 (16.3)	28 (11.4)	
Good/very good	56 (70.0)	208 (84.6)	
Epilepsy	6 (2.4)	6 (7.5)	.08
Psychiatric care	13 (16.3)	12 (4.9)	.002
Anxiolytic treatment	6 (2.4)	6 (7.5)	.08
Antidepressant treatment	2 (.8)	6 (7.5)	.004
Alcohol use	30 (37.5)	69 (28.1)	.14
Regular alcohol use	10 (12.5)	17 (6.9)	.13
Cannabis use	34 (42.5)	77 (31.3)	.12
Regular cannabis use	23 (28.7)	39 (15.9)	.02

<sup>1</sup>Traumatic Brain Injury.

<sup>2</sup>P were calculated with the  $\chi^2$  test or Fisher's exact test when necessary.

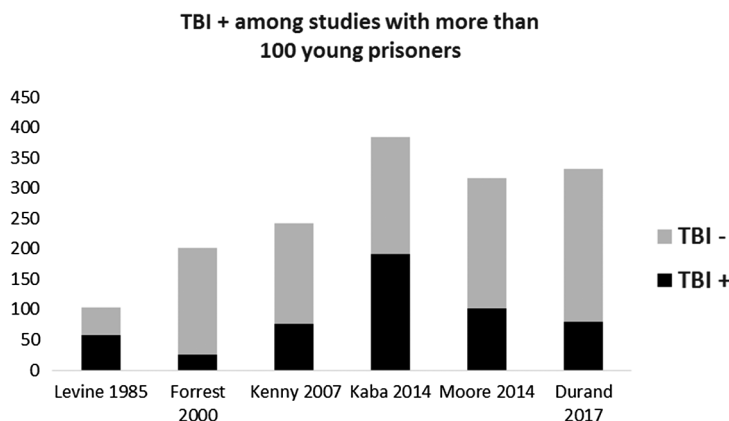
respectively). Perceived health was worse for cases than for controls ( $p = .0009$ ). No difference were found regarding use and regular use of alcohol ( $p = .14$  and  $p = .13$  respectively). However, the regular use of cannabis was significantly higher for cases ( $p = .02$ ). The use of antidepressant treatment was much lower for cases than for controls ( $p = .004$ ) but cases reported significantly more psychiatric follow-up ( $p = .002$ ).

#### 4. Discussion

The main aim of this study was to estimate the prevalence of self-reported TBI in a population of young offenders aged 13 to 21 in a French prison. The study also aimed to study co-variables known to be associated with TBI, such as epilepsy, mental health problems, use of alcohol and/or cannabis and psychoactive medication. The rate of self-reported history of TBI was high for young people, with an overall prevalence of 24.5%. The majority of TBIs were sustained during adolescence (44/80). The first TBI occurred before the first imprisonment in 73/80 case (92.3%). Cases and controls were of the same age ( $p = .19$ ) and they both had their first contact with the prison around 18 ( $p = .96$ ). No difference were found regarding the number of times in custody and the total time spent in jail during the preceding five years ( $p = .11$  and  $p = .16$  respectively). Young offenders who reported a TBI significantly accumulate multiple health problems including mental health problems (16.3%;  $p = .002$ ) and a regular use of cannabis (28.7%;  $p = .02$ ).

This study is the first to report on the prevalence of TBI among young offenders in France. Among studies looking at the prevalence of TBI among young offenders, the prevalence ranges from 16.5 to 72.1% with a rate of a 100% reported among a sample of 15 young people sentenced to death (Hughes et al., 2015; Lewis, Pincus, Feldman, Jackson, & Bard, 1986). In our study, the rate of 24.5% can be considered comparable to findings of studies having used a sample of a similar size (between 100 and 500 young offenders) (Forrest, Tambor, Riley, Ensminger, & Starfield, 2000; Kaba, Diamond, Haque, MacDonald, & Venters, 2014; Kenny & Lennings, 2007; Levine, Karniski, Palfrey, Meltzer, &

**Figure 1. Prevalence of TBI among studies with more than 100 young prisoners.**



Fenton, 1985; Moore, Indig, & Haysom, 2014) (Figure 1). This study confirms previous findings published in Australia, the United Kingdom and the United States.

As data about the prevalence of TBI are lacking for Europe (regarding adult and young prisoner populations), it is hazardous to compare our results with the prevalence of a history of TBI in the general population (Tagliaferri, Compagnone, Korsic, Servadei, & Kraus, 2006). No data are available in France about the prevalence of TBI among young people (<21 years). That said, some studies performed in Canada, New Zealand and the United States indicated that prevalence rates vary from 4.7 to 35% depending on the definition used for TBI (any head injury, head injury resulting in LOC ...) (Ilie, Boak, Adlaf, Asbridge, & Cusimano, 2013).

In our population of young offenders and according to the definition used, moderate (hospitalisation without a coma) or severe TBI (hospitalisation and a coma) represented 27.5% of all declared TBI which is higher than what is usually described in the population as a whole (around 20%). Published studies also indicate that young people are more likely to have a high prevalence of mild TBI, particularly concussions from sport (Daneshvar, Nowinski, McKee, & Cantu, 2011; Marar, McIlvain, Fields, & Comstock, 2012; Rosenthal, Foraker, Collins, & Comstock, 2014). There is also evidence that decreased likelihood of reporting mild TBI can be the result of pressures from teammates, friends and parents (Kroshus, Garnett, Hawrilenko, Baugh, & Calzo, 2015). The rate of TBI resulting from sporting accidents was very low in our population.

The findings of this study indicate that the leading cause of TBI in prison is violence-related mechanisms (25%). In this study, violence-related mechanisms included gunshot wounds and fights. This result confirmed previous findings among young offender populations (Chitsabesan, Lennox, Williams, Tariq, & Shaw, 2015; Hux, Bond, Skinner, Belau, & Sanger, 1998; Kaba et al., 2014; Lewis et al., 1986). In the Paris region (PariS-TBI), in a large prospective longitudinal study on severe TBI (PariS-TBI;  $n = 504$ ), the main causes of severe TBI were RTAs (53% of patients) and falls (35%) (Jourdan et al., 2013). Violence-related mechanisms were responsible for 5.4% of severe TBI over the whole age range. Among the youngest patients (15–21;  $n = 78$ ) however, violence related mechanisms were responsible for only 1% of severe TBI (Jourdan, personal communication). In the USA, about 10% of all cases of TBI are due to violence-related mechanisms (assaults), which is more than the figure published recently in France (CDC, 2003; Jourdan et al., 2013; Langlois et al., 2006). The high prevalence of violence-related mechanisms in our study could be explained by the fact that young males who sustained a TBI resulting from a violent cause are more likely to develop a criminality and to be arrested, as previously reported (Elbogen et al., 2015).

In this study, the rate of self-reported epilepsy (4%) was much higher than in the population as a whole (.5% in France). This high prevalence might be explained by fronto-temporal epilepsy among children which causes behavioural disorders or epilepsy in relation with withdrawal syndromes after



the use of alcohol or other psycho-active substances. However, in this sample, epilepsy was found to be lower for cases (2.4%) than for controls (7.5%), although not significantly ( $p = .08$ ). Further research is needed to understand this result. It was also lower than the prevalence found among male offenders which was 6% (Durand et al., 2016a).

Perceived health was worse for young offenders who reported a TBI than for those who did not. That could be explained by the fact that young offenders who reported a TBI accumulate multiple health problems, including mental health problems and a regular use of cannabis. These findings are not surprising and are in accordance with other studies looking at the association between TBI and comorbidity (Hughes et al., 2015; Williams, Cordan, Mewse, Tonks, & Burgess, 2010a). Regarding mental health problems, a study has recently found that the prevalence of deliberate self-harm and suicide risk factors was significantly increased in those having experienced a TBI (Chitsabesan et al., 2015).

The results of this study also highlight the question of the association between criminality and TBI among young offenders. According to some authors, violence and criminal behaviour may be a consequence of a history of TBI during childhood or adolescence (Fazel et al., 2011; Timonen et al., 2002). TBI history is also associated with mental health problems and the use of alcohol (Timonen et al., 2002). Among studies looking at mental health problems in prisoners, the most frequently reported disorder is depression (Schofield et al., 2006a, 2006b; Slaughter, Fann, & Ehde, 2003; Walker, Hiller, Staton, & Leukefeld, 2003). In our sample, young offenders who reported a TBI also reported a greater regular use of cannabis and more mental health problems than those who didn't report a TBI. Nevertheless, little is known about the status of offenders before they enter the custodial system. A recent study suggested that caution should be used before any conclusion about the relationship between TBI and behavioral or cognitive disorders (Nordstrom, Benoni, Lindstrom, & Nordstrom, 2013). Moreover, TBI could only be a marker for several factors including psychosocial adversity (Chitsabesan et al., 2015). The survey population is young (17.8 years for females and 18.9 for males) with low levels of education and employment. These characteristics are similar to those usually found in offender populations, but also among populations having sustained a TBI (Godin-Blandeau, Verdot, & Develay, 2013; Jourdan, Bayen et al., 2013; Jourdan, Bosserelle et al., 2013; Mouquet, 2005; Mouquet et al., 1999; Watson, Stimpson, & Hostick, 2004). Studying the association and/or the link between criminality and TBI is then even more delicate because there are a number of common characteristics between prison populations and TBI populations especially for the 15–25 years incidence's peak (Table 6).

In our study, the first TBI occurred before the first imprisonment in 73/80 case (92.3%). However, unlike Williams' study which included male offenders (from 18 to 54 years old), no difference was found between cases and controls regarding the age of their first contact with the custodial system (Williams et al., 2010b). The findings of this study on comparisons between cases and controls in the young offender population also suggest that there is no difference regarding the total time spent in prison or the number of additional imprisonment. These results could be due to the homogeneously young age of our sample and need to be enquired further.

**Table 6. Common characteristics between TBI populations and prison populations**

Population	TBI populations	Prison populations
Age	Young people (incidence peak 15-25)	Young people (Mean age around 30)
Sex-ratio	75% males	95.6% males
Level of education	Low = risk factor to sustain a TBI	Low
Socio-economic status	Low = risk factor to sustain a TBI	Low
Use of alcohol and drugs	Alcohol and drugs = risk factor Alcohol after TBI	High prevalences of use of alcohol, tobacco and cannabis
Psychiatric and psychological disorders	More frequent before and after a TBI than in the population as a whole	More frequent than in the population as a whole
Cognitive disorders	Possible sequelea	Possible cognitive disorders

Even if the nature of the relationship between TBI and criminality needs further exploration, these findings could be of major interest for the management and rehabilitation of young offenders. Some studies suggest that TBI may be associated with offending or re-offending among juveniles (Levine et al., 1985; Lewis et al., 1986; Perron & Howard, 2008; Williams et al., 2010b). TBI itself may also be responsible for aggression and violent behaviors (Tateno, Jorge, & Robinson, 2003). In our sample, the leading cause of reported TBI was violence-related mechanisms (25%) and 28/80 experienced more than one TBI. Multiple mild TBIs can cause cognitive and behavioural profiles similar to those observed following severe TBI (Diamond, Harzke, Magaletta, Cummins, & Frankowski, 2007). Moreover, our findings indicate that only 14/80 of young offenders who reported a TBI did benefit from a subsequent follow-up. The findings of this study suggest that clinicians should use multiple approaches for these patients. Offenders reporting a history of moderate to severe or repeated mild TBI should be assessed by specialists in the field of neurological rehabilitation, substance dependence and psychiatry. As they can be associated with TBI, focus should be placed on the early evaluation of aggressive and violent behaviours during the first weeks or months following a TBI. This evaluation should take place in specialised medical wards. Rehabilitation should involve, whenever required, professionals from the health and social fields. Whenever patients become involved with the criminal system, professionals from the justice field should also be involved because prisoners with a history of TBI may have more difficulties to adapt to prison life (O'Sullivan, Glorney, Sterr, Oddy, & da Silva Ramos, 2015). In order to prevent reoffending, a specific approach should be developed for young offenders including the development of a specialist brain injury linkworker service as it was done in the United Kingdom (Chitsabesan et al., 2015). Since, as far as we know, there is no systematic screening for TBI on arrival in prison in France, this could lead to further inequities in access to medical care.

#### **4.1. Limitations**

Our study is cross-sectional and as data were collected by means of an interview (self-report), the results should be interpreted with caution. Since, however, the reliability of prisoners responses is frequently challenged, it is interesting that a study involving 200 Australian prisoners highlighted that inmates' responses to questionnaires corresponded closely to the reality (Schofield, Butler, Hollis, & D'Este, 2011). These findings run counter to the conventional wisdom that responses by the criminal population are dishonest and therefore unusable.

One could also argue a recall bias, which is an error caused by differences in the accuracy or completeness of the recollections retrieved by participants regarding past events or experiences. As cases and controls were of the same mean age, results about differences can be considered strong enough to be discussed.

Neither of these limitations affects the primary aims of this study which were to establish the prevalence of TBI in a representative population of young offenders in a French prison.

#### **5. Conclusion**

This study confirms the high prevalence of TBI among young offenders in prison. These results are consistent with previous studies using the same method. They also provide further evidence that, even though TBI has been previously identified as an issue for young offender populations, there is a need to develop a specific policy. The first step would be to develop systematic screening for TBI upon arrival, to build up knowledge about its prevalence, and to organize training for prosecutors, judges and physicians working in prisons. Further studies should help in understanding and proving (or not) the possible association of TBI with criminality. Future steps should include carrying out a cohort study among persons of the general population who sustained a TBI with the object of elucidating the possible links between these two issues.

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