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Non-suicidal self-harm in prison: A national population-based study

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ABSTRACT

Prisoners are at risk of self-harm during incarceration, yet national estimates of the rate and risk factors of self-harm are rare. We aimed to examine the rate and risk factors of self-harm on aggregate and by sex using a national population-based study design. Israel Prison Service data were examined on all persons incarcerated for a criminal offense 2009–2015 (N = 263,794). Self-harm was ascertained from real-time recorded observations. The study covariates were: demographic, criminal history, and prison environment factors. The association between the risk of self-harm and study covariates was estimated with relative risks and their corresponding 95% confidence intervals fitted with a Poisson regression model. During the seven-year study period of 237,945 (91%) males and 25,849 (9%) females, 1761 inmates (0.7%) inflicted self-harm. In the total population, among females and males the relative risk of self-harm was statistically significantly (FDR $P < 0.05$) consistently associated with: involvement in prison misconduct, violent behavior, and verbal threats of self-harm. Risk factors that occur during incarceration may offer immediate information to assess the risk of self-harm and to develop prevention strategies.

1. Introduction

Non-suicidal self-harm refers to a deliberate, self-inflicted destruction of body tissue without suicidal intent (Dixon-Gordon et al., 2012). During incarceration, self-harm is relevant to inmate security and welfare and poses a major clinical challenge that makes the identification of risk factors for self-harm an international priority (Dixon-Gordon et al., 2012). However, consensus is lacking as to which risk factors predict self-harm during incarceration (Hawton et al., 2014), particularly accounting for sex. In addition, estimates of the rate of self-harm vary across studies.

Across studies the rates of self-harm range from 0.71% (Appelbaum et al., 2011) or 2.4%, (0.7% for serious self-harm) (Smith and Kaminski, 2011) to 10% during incarceration (Preti and Cascio, 2006), compared with from 0.6% (Bebbington et al., 2010) to 4% (Klonsky et al., 2003) in community-based samples. The rates of self-harm during incarceration vary across studies possibly owing to different definitions, measures and methods of measurement of self-harm (e.g., acts requiring medical attention, prison guard observations, self-report) and/or heterogeneity in the way self-harm is documented or reported across prisons.

Population-based studies of prisoners during incarceration have identified the following demographic risk factors of self-harm: female sex, young age (Hawton et al., 2014), and foreign citizenship (Preti and Cascio, 2006). Epidemiologic studies (Casiano et al., 2013; DeHart et al., 2009; Smith and Kaminski, 2010) have also shown that some aspects of criminal history, especially a history of violence (Sahlin et al., 2017; Webb et al., 2017) are associated with the risk of self-harm. Other study designs have shown that a history of drug-related crime (Fotiadou et al., 2006) and having more prior admissions in prison are associated with self-harm (Fagan et al., 2010; Lanes, 2009), but these associations are yet to be scrutinized in national population-based data or separately by prisoner sex (Hawton et al., 2014). Prison environment factors associated with the risk of self-harm include: violent behavior (Lanes, 2009, 2011), inmate misconduct while in custody (Fotiadou et al., 2006; Smith and Kaminski, 2011), and placement in solitary confinement (Kaba et al., 2014; Lanes, 2011). Verbal threats of self-harm, however, have not been empirically examined, despite their clinical lure and potential relevance for preventative measures (DeHart et al., 2009; Haycock, 1989). Furthermore, one study reported that the risk factors for self-harm differ by sex for prison type and not demographic factors (Hawton et al., 2014). However, the associations between the risk of self-harm with the aforementioned criminal history and prison environment factors for each sex are yet are be examined.

The current study aims to examine the rate and risk factors for non-suicidal self-harm in Israeli prisons using a complete national population-based study design.

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2. Methods

2.1. Population

A national population-based study design was formed with data from the Israeli Prison Service (IPS). The IPS is the national prison system of the State of Israel that houses inmates in 33 prisons. Until the 2008 reform of the IPS, part of Israel's prisons has been under auspices of the Israeli police. Hence, IPS data on inmates in all institutions were available from the beginning of 2009. The end of the follow-up period was determined by the IPS ethics board. Thus, 2009–2015 was the study time-frame. Data consisted of incarceration intake information on demographic factors and criminal history, in addition to information on prison environment-related factors that are recorded in-real-time and continuously maintained (i.e., instances of solitary confinement, prison misconduct, prison violent behavior, hunger strike, verbal threats to self-harm and self-harm).

The source population included all persons admitted to all prisons of the IPS between January 1, 2009 and December 31, 2015 (N = 263,794) for at least one day for any criminal charge. Security inmates and persons admitted in prison for non-criminal offences (e.g., failure to pay a child support) were not included in the study. Ethical approval was attained from the IPS and IRB at the University of Haifa with all participants in the data de-identified and a waiver of informed consent. The study was therefore performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

2.2. Study outcome: ascertainment of self-harm

Following an incident of self-harm in the IPS several routine responses are implemented. These include requiring medical or psychiatric attention, recording of the date of self-harm in the inmate's file in the IPS management system by specially trained prison staff. Then, as a part of the clinical assessment, a senior service provider (typically a social worker, often after consulting a psychiatrist) determines whether or not an act constituted non-suicidal self-harm. In our study, every incident of self-harm was reviewed independently by one researcher (author DV) to ensure that each case described an act of non-suicidal self-harm. Cases of self-harm were defined for prisoners with recorded acts of self-inflicted non-suicidal self-harm during the study period.

2.3. Covariates

Demographic risk factors included inmate age (classified as born in 1969 or before or in 1970 and after), sex (classified as female or male), and nation of origin (classified as Israeli or non-Israeli). Criminal history during the study period was classified separately as the presence or absence of each of the following offense groups: violence offences, sex offences, drug offences, public order offences, property offences, road offences, immigration offences, fraud offences, economic offences, conspiracy offences, justice offences, and other offences (each defined in online supplement eTable 1). Thus of the aforementioned 12 offense groups formed a distinct covariate. The number of prior admissions in prison was classified into three groups: none, one and more than one. Similarly to the criminal history covariates, five aspects to the prison environment were each classified as present or absent and each was a covariate. These were: prison misconduct, violence, hunger strike, solitary confinement and verbal threats of self-harm (each defined in eTable 2 in the supplement).

2.4. Statistical analysis

First, we examined the sample characteristics. Second, missing data were imputed using the missForest library in R because it has been reported to outperform many other imputation methods (Stekhoven and Bühlmann, 2012). We examined the extent of error through the use of missing data imputation with missForest following widely cited guidelines (Stekhoven, 2016; Stekhoven and Bühlmann, 2012; Waljee et al., 2013). Third, relative risk of self-harm and the associated two-sided 95% confidence intervals (CI) were estimated by fitting log-linear Poisson regression models (Zou, 2004), as used in prior research (Stekhoven, 2016; Stekhoven and Bühlmann, 2012; Waljee et al., 2013). Each of the aforementioned study covariates was first without adjusting for any covariates ('crude model') and adjusted for the study covariates in a multivariate model like prior self-harm studies (e.g., Hawton et al., 2014). Each prisoner was followed-up from incarceration until the first recorded incident of self-harm, release, death, or end of follow-up on December 31, 2015, whichever came first. The primary analysis was computed for the total population and then in sensitivity analysis replicated exactly by sex separately, except without the sex covariate. All tests of statistical significance were reported at the nominal two-sided 5% level of significance and then were reported the P-value adjusted for the false discovery rate (FDR; Benjamini and Hochberg, 1995). All analyses were performed in R version 3.4 (see code in eTable 3).

3. Results

Missing data were observed on the following covariates: birth year (n = 2619; 1%), sex (n = 38,312; 14.5%), and number of prior admissions (n = 129; 0%). The missing information was imputed using missForest. The normalized root mean squared error (NRMSE) for the continuous part of the imputed data was 0.00. The proportion falsely classified (PFC) for the categorical part of the imputed data was 0.04. In both cases the performance of data imputation was good because the values are close to zero (values around 1 indicate the performance of missing data imputation was bad which was not the case here).

The sample characteristics of the population are presented in the Table 1 to describe the prisoners who did and did not subsequently inflict self-harm. The population consisted of 263,794 prisoners with 5,740,775 person-years of follow-up. During the 7 years of study period, 1,761 (0.7%) inmates had a recorded instance of self-harm, a rate of 31 per 100,000 person-years.

3.1. Relative risk of self-harm

In the total population the adjusted relative risk of self-harm had a statistically significant (FDR P-value < 0.05) association with: female sex, one or more prior incarcerations, and involvement in property, sex, fraud, and violence offences, involvement in hunger strikes, prison misconduct, violent behavior and verbal threats of self-harm (Table 2). The remaining covariates had a null association with self-harm in the total population.

In sensitivity analysis among the male population the relative risk of self-harm had a statistically significant (FDR P-value < 0.05) association with: one or more prior admissions in prison, had committed drug, immigration, violence, sex, property, and fraud offences, involvement in prison misconduct, violent behavior, hunger strike and verbal threats of self-harm. In sensitivity analysis among the female population the relative risk of self-harm had a statistically significant (FDR P-value < 0.05) association with: younger age (born at 1970 or after), and involvement in prison misconduct, violent behavior, and verbal threats of self-harm (Table 3).

4. Discussion

Using a national population-based study design, the current study examined the rate and associations between demographic, criminal history and prison environment factors with the risk of self-harm during incarceration in the total population and by sex. The rate of self-harm was 0.7%. The current study results were the first to show consistent associations between prison-environment risk factors and the risk of

Table 1
Sample characteristics by self-harm.

Covariate	Covariate category	Self-harm present *n* (%)	Self-harm absent *n* (%)	*p*
N		1761	262,033	
Decade of birth	<1970	314 (17.8)	47,068 (18.0)	0.910
	>=1970	1447 (82.2)	214,965 (82.0)	
Sex	Male	1648 (93.6)	236,297 (90.2)	<0.001
	Female	113 (6.4)	25,736 (9.8)	
Country of birth	Non-Israeli	723 (41.1)	189,385 (72.3)	<0.001
	Israeli	1038 (58.9)	72,648 (27.7)	
Prior admissions	None	707 (40.1)	214,050 (81.7)	<0.001
	1	266 (15.1)	24,317 (9.3)	
	>1	788 (44.7)	23,666 (9.0)	
Drug offences	Absent	1320 (75.0)	240,593 (91.8)	<0.001
	Present	441 (25.0)	21,440 (8.2)	
Immigration offences	Absent	1433 (81.4)	158,426 (60.5)	<0.001
	Present	328 (18.6)	103,607 (39.5)	
Violence offences	Absent	478 (27.1)	180,289 (68.8)	<0.001
	Present	1283 (72.9)	81,744 (31.2)	
Sex offences	Absent	1579 (89.7)	253,540 (96.8)	<0.001
	Present	182 (10.3)	8493 (3.2)	
Economic offences	Absent	1681 (95.5)	256,864 (98.0)	<0.001
	Present	80 (4.5)	5169 (2.0)	
Justice offences	Absent	1022 (58.0)	231,789 (88.5)	<0.001
	Present	739 (42.0)	30,244 (11.5)	
Property offences	Absent	616 (35.0)	210,365 (80.3)	<0.001
	Present	1145 (65.0)	51,668 (19.7)	
Fraud offences	Absent	1610 (91.4)	253,082 (96.6)	<0.001
	Present	151 (8.6)	8951 (3.4)	
Public order offences	Absent	1257 (71.4)	238,072 (90.9)	<0.001
	Present	504 (28.6)	23,961 (9.1)	
Other offences	Absent	1217 (69.1)	218,281 (83.3)	<0.001
	Present	544 (30.9)	43,752 (16.7)	
Conspiracy offences	Absent	1587 (90.1)	249,993 (95.4)	<0.001
	Present	174 (9.9)	12,040 (4.6)	
Road offences	Absent	1529 (86.8)	245,898 (93.8)	<0.001
	Present	232 (13.2)	16,135 (6.2)	
Solitary confinement	Absent	1442 (81.9)	260,228 (99.3)	<0.001
	Present	319 (18.1)	1805 (0.7)	
Prison misconduct	Absent	839 (47.6)	251,419 (95.9)	<0.001
	Present	922 (52.4)	10,614 (4.1)	
Hunger strike	Absent	1572 (89.3)	260,587 (99.4)	<0.001
	Present	189 (10.7)	1446 (0.6)	
Violent behavior	Absent	840 (47.7)	250,979 (95.8)	<0.001
	Present	921 (52.3)	11,054 (4.2)	
Verbal threats of self-harm	Absent	867 (49.2)	256,793 (98.0)	<0.001
	Present	894 (50.8)	5240 (2.0)	

self-harm.

During this seven year study a total of 0.7% ($n = 1761$) of prisoners had recorded incidents of non-suicidal self-harm during incarceration. The rate of self-harm in the current study population resembles those in some other studies that reported rates of under 0.71% (Appelbaum et al., 2011) and 0.7% for serious self-harm (Smith and Kaminski, 2011) based on a survey study design. One reason for the low self-harm rate may be cultural and religious (i.e., Israel has a lower suicide rate than other nations (Gvion et al., 2014). Other tentative reasons for the low rate of self-harm may reflect prisoner assessment at intake, policies and/or intense supervision during incarceration and/or because our study ascertained of self-harm sufficiently serious to warrant medical and/or psychiatric treatment. This suggests that our rate may reflect serious self-harm.

At the total population-level our results were similar to prior research. Consistent with a recent population-based study, female sex and younger age (Hawton et al., 2014) were significantly associated with an increased risk of self-harm. However, in a prior Italian population-based study (Preti and Cascio, 2006), foreign citizenship was a risk factor for self-harm, whereas in our study native birth in Israel was not associated with increased risk for self-harm. Ours was the first study to identify several criminal history factors associated with the risk of self-harm. Specifically, involvement in property offences and sex offences was associated with the risk of self-harm. Other aspects of criminal history (i.e., fraud, immigration offences) were statistically associated with the risk for self-harm. Finally, we replicated prior results that more prior incarcerations (Fagan et al., 2010; Lanes, 2009) and a history of violence (Sahlin et al., 2017; Webb et al., 2017) and drug offending (Fotiadou et al., 2006) are associated with an elevated risk of self-harm. A possible mechanism for these criminal history risk factors is the shame of incarceration. We replicated the results from prior studies that prison misconduct (Fotiadou et al., 2006; Smith and Kaminski, 2010) and violent behavior (Lanes, 2009,2011) are associated with the risk of self-harm.

Extending prior research, our results point to separate risk profiles for each sex. Among female prisoners the risk of self-harm was associated with being younger (born 1970 or after), and during incarceration involvement in misconduct, violent behavior, and verbal threats of self-harm. This suggests that observable risk factors pertaining to the harshness of the prison environment increase the risk of self-harm among younger females. Male prisoners were at risk of self-harm if they had been recidivists (having one or more prior admissions in prison), had an history of drug, immigration, violence, sex, property, and fraud offences, and had been involved in prison misconduct, violent behavior against others, hunger strikes and verbal threats of self-harm). Collectively, these findings offer tentative support that male prisoners vulnerable to self-harm may exhibit externalizing spectrum symptoms (Vaughn et al., 2014) with disobedience to authority (evidenced by

Table 2
Crude and adjusted estimates of self-harm in the total population.

Covariate	Covariate category	Crude estimates				Adjusted estimates			
		Relative risk	95% CI	*P*-value	*P*-value FDR adjusted	Relative risk	95% CI	*P*-value	*P*-value FDR adjusted
Birth year	<1970	Reference group				Reference group			
	>=1970	1.01	0.89–1.14	0.89	0.89	1.12	0.99–1.27	0.06	0.09
Sex	Male	Reference group				Reference group			
	Female	0.63	0.52–0.76	0.00	0.00	1.60	1.31–1.95	0.00	0.00
Country of birth	Non-Israeli	Reference group				Reference group			
	Israeli	3.70	3.37–4.07	0.00	0.00	1.11	0.99–1.24	0.08	0.11
Prior admissions	0	Reference group				Reference group			
	1	3.30	2.86–3.78	0.00	0.00	1.53	1.32–1.77	0.00	0.00
	>1	9.79	8.85–10.82	0.00	0.00	1.93	1.70–2.20	0.00	0.00
Drug offences	Absent	Reference group				Reference group			
	Present	3.70	3.32–4.11	0.00	0.00	1.13	1.01–1.26	0.03	0.06
Immigration offences	Absent	Reference group				Reference group			
	Present	0.35	0.31–0.40	0.00	0.00	1.14	0.98–1.32	0.08	0.11
Violence offences	Absent	Reference group				Reference group			
	Present	5.84	5.26–6.49	0.00	0.00	1.86	1.63–2.12	0.00	0.00
Sex offences	Absent	Reference group				Reference group			
	Present	3.40	2.91–3.94	0.00	0.00	1.47	1.27–1.71	0.00	0.00
Economic offences	Absent	Reference group				Reference group			
	Present	2.34	1.88–2.93	0.00	0.00	0.98	0.79–1.22	0.85	0.89
Justice offences	Absent	Reference group				Reference group			
	Present	5.43	4.95–5.97	0.00	0.00	1.11	1.00–1.24	0.06	0.09
Property offences	Absent	Reference group				Reference group			
	Present	7.43	6.74–8.19	0.00	0.00	1.93	1.70–2.19	0.00	0.00
Fraud offences	Absent	Reference group					Reference group		
	Present	2.64	2.22–3.10	0.00	0.00	1.35	1.14–1.59	0.00	0.00
Public order offences	Absent	Reference group				Reference group			
	Present	3.92	3.54–4.35	0.00	0.00	1.08	0.97–1.21	0.14	0.17
Conspiracy offences	Absent	Reference group				Reference group			
	Present	2.26	1.93–2.64	0.00	0.00	0.88	0.76–1.03	0.12	0.15
Road offences	Absent	Reference group				Reference group			
	Present	2.30	2.01–2.63	0.00	0.00	0.95	0.83–1.09	0.47	0.54
Other offences	Absent	Reference group				Reference group			
	Present	2.21	2.00–2.45	0.00	0.00	1.00	0.90–1.11	0.94	0.94
Solitary confinement	Absent	Reference group				Reference group			
	Present	27.25	24.33–30.53	0.00	0.00	1.02	0.89–1.17	0.80	0.88
Prison misconduct	Absent	Reference group				Reference group			
	Present	24.03	21.93–26.37	0.00	0.00	2.72	2.34–3.17	0.00	0.00
Violent behavior	Absent	Reference group				Reference group			
	Present	23.06	21.04–25.27	0.00	0.00	2.64	2.28–3.06	0.00	0.00
Hunger strike	Absent	Reference group				Reference group			
	Present	19.28	16.71–22.24	0.00	0.00	1.39	1.19–1.62	0.00	0.00
Verbal threat of self-harm	Absent	Reference group				Reference group			
	Present	43.31	39.60–47.39	0.00	0.00	7.10	6.11–8.25	0.00	0.00

Note. Abbreviations: RR, Relative Risk, FDR, False Discovery Rate, CI, Confidence Interval.

hunger strikes) feelings of distress, shame of incarceration and negative affect (Vaughn et al., 2009) amplified by stressors of the prison environment (Rivlin et al., 2013).

Irrespective of sex, for the first time in the literature, our results identified that the risk of self-harm was significantly associated with prison misconduct, violent behavior and verbal threats of self-harm during incarceration. These are observable risk factors that all occur within the prison environment. Hence, possibly as the prison environment is common to these risk factors, stress and maladaptation to incarceration may be mechanisms responsible for these associations (Rivlin et al., 2013). These risk factors were studied after partialing out demographic and criminal history factors, yet were associated with the risk of self-harm irrespective of sex. This result is contrary to a common view among prison staff that verbal threats are merely manipulative (Dear et al., 2000; DeHart et al., 2009). Rather our finding suggests that verbal threats of self-harm are worthy of attention by those involved in self-harm prevention.

4.1. Limitations and conclusions

Our findings need to be considered in the light of at least three major limitations. First, prior research has shown that a history of a psychiatric diagnosis is a risk factor for self-harm during incarceration (Fazel and Danesh, 2002; Fotiadou et al., 2006; Mohino Justes et al., 2004). Unfortunately, psychiatric diagnoses were unavailable to us. Hence confounding by psychiatric diagnosis may have occurred. However, like our study, diagnoses of psychiatric disorders were also not included in the epidemiological study of prisoner self-harm in England and Wales (Hawton et al., 2014). This may reflect the difficulty of obtaining prison psychiatric information internationally owing to data security provisions pertaining to considerations of prisoner anonymity and confidentiality. Second, unfortunately, owing to data security considerations of the IPS we lacked information to account for the within prison correlation. Third, misclassification of self-harm may have occurred, distorting the magnitude of the estimated risk reduction in the results. It is possible that misclassification was in the direction of under-reporting. This form of misclassification is in the direction of false-negatives. False-negative classification of outcome may narrow the difference between the cases and control groups. This may result in a more conservative comparison than without false-negative misclassification. This suggests that had self-harmers classified as false-negatives been accurately identified, the results would be more pronounced than they were. False-positive misclassification may also have occurred (self-harm when non-occurred). Third, we could not adjust for within prison variability unlike other studies (Hawton et al., 2014) due to data confidentiality. The possible adjustment by prison variability

Table 3
Adjusted relative risk of self-harm for each sex separately.

Covariate	Covariate category	Females				Males			
		Relative risk	95% CI	*P*-value	*P*-value FDR adjusted	Relative risk	95% CI	*P*-value	*P*-value FDR adjusted
Birth year	<1970	Reference group				Reference group			
	>=1970	1.86	1.14–3.03	0.01	0.05	1.07	0.95–1.22	0.26	0.32
Country of birth	Non-Israeli	Reference group				Reference group			
	Israeli	1.76	1.10–2.83	0.02	0.06	1.08	0.96–1.21	0.21	0.27
Prior admissions	0	Reference group				Reference group			
	1	1.68	0.83–3.38	0.15	0.31	1.50	1.29–1.74	0.00	0.00
	>1	1.40	0.73–2.69	0.32	0.53	1.94	1.70–2.21	0.00	0.00
Drug offences	Absent	Reference group				Reference group			
	Present	0.88	0.49–1.60	0.69	0.76	1.15	1.03–1.29	0.02	0.03
Immigration offences	Absent	Reference group				Reference group			
	Present	0.43	0.21–0.86	0.02	0.06	1.22	1.05–1.41	0.01	0.02
Violence offences	Absent	Reference group				Reference group			
	Present	2.00	1.12–3.57	0.02	0.06	1.81	1.58–2.07	0.00	0.00
Sex offences	Absent	Reference group				Reference group			
	Present	2.36	0.42–13.14	0.33	0.53	1.48	1.27–1.72	0.00	0.00
Economic offences	Absent	Reference group				Reference group			
	Present	1.06	0.50–2.22	0.88	0.88	0.97	0.78–1.23	0.83	0.84
Justice offences	Absent	Reference group				Reference group			
	Present	1.16	0.73–1.84	0.53	0.65	1.11	0.99–1.23	0.08	0.13
Property offences	Absent	Reference group				Reference group			
	Present	1.69	0.98–2.91	0.06	0.16	1.93	1.70–2.20	0.00	0.00
Fraud offences	Absent	Reference group					Reference group		
	Present	0.69	0.25–1.91	0.47	0.62	1.34	1.14–1.59	0.00	0.00
Public order offences	Absent	Reference group				Reference group			
	Present	1.36	0.79–2.37	0.27	0.52	1.08	0.97–1.21	0.15	0.21
Conspiracy offences	Absent	Reference group				Reference group			
	Present	1.40	0.59–3.34	0.45	0.62	0.89	0.76–1.04	0.14	0.21
Road offences	Absent	Reference group				Reference group			
	Present	0.86	0.26–2.82	0.80	0.84	0.96	0.84–1.10	0.57	0.66
Other offences	Absent	Reference group				Reference group			
	Present	0.78	0.47–1.32	0.36	0.54	1.01	0.91–1.13	0.84	0.84
Solitary confinement	Absent	Reference group				Reference group			
	Present	1.20	0.56–2.60	0.64	0.75	1.02	0.89–1.18	0.75	0.83
Prison misconduct	Absent	Reference group				Reference group			
	Present	6.34	3.10–13.00	0.00	0.00	2.60	2.24–3.03	0.00	0.00
Violent behavior	Absent	Reference group				Reference group			
	Present	2.35	1.19–4.65	0.01	0.05	2.65	2.28–3.07	0.00	0.00
Hunger strike	Absent	Reference group				Reference group			
	Present	2.12	0.84–5.40	0.11	0.26	1.37	1.17–1.60	0.00	0.00
Verbal threat of self-harm	Absent	Reference group				Reference group			
	Present	2.94	1.50–5.73	0.00	0.00	7.39	6.34–8.62	0.00	0.00

Note. Abbreviations: FDR, False Discovery Rate, CI, Confidence Interval.

would possibly widen our confidence intervals.

We lacked information to examine the associations between self-harm with attempted and completed suicide. Ascertaining these associations is relevant because self-harm is likely a risk factor for suicide, which has a high rate among prisoners (Fazel et al., 2011). Nonetheless, self-harm is often sufficiently serious to warrant medical attention and/or therapeutic action by prison staff.

Mutually exclusive classification of crimes was not possible owing to the combination of rare exposure and outcome (i.e. the permutations of crime by self-harm). This and confounding (observed in differences between the crude and adjusted results by sex) may have reduced the association between criminal history and self-harm and weakens causal arguments with regard to the association between criminal history and self-harm. However, a clinical trial would not be ethical to examine these associations, making this observational study without mutually exclusive classification design a best alternative. A larger sample size would facilitate a mutually exclusive classification in future study.

Despite its limitations, a strength of the current study is the inclusion of a large, prospective, population-based cohort of prisoners incarcerated within a specific time period, with recent and close to complete coverage of the study covariates. In instances where there was missing information, imputation was imputed with low error levels.

Using a current population-based study design, the results identified risk factors of self-harm in prison. In addition to the replication of many prior findings, our study was the first to identify that several criminal history factors (e.g., property offences, sex offences, fraud offences, and immigration offences), and prison environment factors (e.g., hunger strike and verbal threats of self-harm) that are associated with the risk of self-harm. The results suggest that offender demographic and criminal histories may be retrieved at intake and used for self-harm risk assessment (Marzano et al., 2016). However, increments in predicting the risk of self-harm were observed from prison environment factors (i.e. those ascertained during the incarceration). This was evidenced by the magnitude of the statistical associations between hunger strikes, prison misconduct, violent behavior toward others and verbal threats of self-harm with the increased risk of self-harm. These risk factors ascertained during incarceration appear to offer an ongoing source of information to assess prisoners-at-risk for self-harm and to develop of prevention strategies (Fagan et al., 2010).

Conflict of interest disclosures

In unrelated work Levine received research support from Shire Pharmaceuticals that is irrelevant to this study. Vinokur is an employee of the Israel Prison Service. The Israel Prison Service played no role in the study design.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2018.12.103.

References

Appelbaum, K.L., Savageau, J.A., Trestman, R.L., Metzner, J.L., Baillargeon, J., 2011. A national survey of self-injurious behavior in American prisons. Psychiatr. Serv. 62, 285–290. https://doi.org/10.1176/appi.ps.62.3.285.

Bebbington, P.E., Minot, S., Cooper, C., Dennis, M., Meltzer, H., Jenkins, R., et al., 2010. Suicidal ideation, self-harm and attempted suicide: results from the British psychiatric morbidity survey 2000. Eur. Psychiatry 25, 427–431. https://doi.org/10.1016/j.eurpsy.2009.12.004.

Benjamini, Y., Hochberg, Y., 1995. Controlling the false discovery rate: a practical and powerful approach to multiple testing. J. R. Stat. Soc. Ser. B. 57 (1), 289–300. https://doi.org/10.2307/3866483.

Casiano, H., Katz, L.Y., Globerman, D., Sareen, J., 2013. Suicide and deliberate self-injurious behavior in juvenile correctional facilities : a review. J. Can. Acad. Child Adolesc. Psychiatry 22 (2), 118–124.

Dear, G.E., Thomson, D.M., Hillls, A.M., 2000. Self-harm in prison: manipulators can also be suicide attempters. Crim. Justice Behav. 27, 160–175. https://doi.org/10.1177/009385480002700200 2.

DeHart, D.D., Smith, H.P., Kaminski, R.J., 2009. Institutional responses to self-injurious behavior among inmates. J. Correct. Health Care 15, 129–141. https://doi.org/10.1177/1078345809331444. quiz 159-160.

Dixon-Gordon, K., Harrison, N., Roesch, R., 2012. Non-suicidal self-injury within offender populations: a systematic review. Int. J. Forensic Ment. Health 11, 33–50. https://doi.org/10.1080/14999013.2012.667513.

Fagan, T.J., Cox, J., Helfand, S.J., Aufderheide, D., 2010. Self-injurious behavior in correctional settings. J. Correct. Health Care 16, 48–66. https://doi.org/10.1177/1078345809348212.

Fazel, S., Danesh, J., 2002. Serious mental disorder in 23 000 prisoners: a systematic review of 62 surveys. Lancet 359, 545–550. https://doi.org/10.1016/S0140-6736(02)07740-1.

Fazel, S., Grann, M., Kling, B., Hawton, K., 2011. Prison suicide in 12 countries: an ecological study of 861 suicides during 2003-2007. Soc. Psychiatry Psychiatr. Epidemiol. 46, 191–195. https://doi.org/10.1007/s00127-010-0184-4.

Fotiadou, M., Livaditis, M., Manou, I., Kaniotou, E., Xenitidis, K., 2006. Prevalence of mental disorders and deliberate self-harm in Greek male prisoners. Int. J. Law Psychiatry. 29, 68–73. https://doi.org/10.1016/j.ijlp.2004.06.009.

Gvion, Y., Levi-Belz, Y., Apter, A., 2014. Suicide in Israel-an update. Crisis 35, 141–144. https://doi.org/10.1027/0227-5910/a000239.

Hawton, K., Linsell, L., Adeniji, T., Sariaslan, A., Fazel, S., 2014. Self-harm in prisons in England and Wales: an epidemiological study of prevalence, risk factors, clustering, and subsequent suicide. Lancet 383, 1147–1154. https://doi.org/10.1016/S0140-6736(13)62118-2.

Haycock, J., 1989. Manipulation and suicide attempts in jails and prisons. Psychiatr. Q. 60, 85–98.

Kaba, F., Lewis, A., Glowa-Kollisch, S., Hadler, J., Lee, D., Alper, H., et al., 2014. Solitary confinement and risk of self-harm among jail inmates. Am. J. Public Health 104, 442–447. https://doi.org/10.2105/AJPH.2013.301742.

Klonsky, E.D., Oltmanns, T.F., Turkheimer, E., 2003. Deliberate self-harm in a nonclinical population: prevalence and psychological correlates. Am. J. Psychiatry 160, 1501–1508. https://doi.org/10.1176/appi.ajp.160.8.1501.

Lanes, E., 2009. Identification of risk factors for self-injurious behavior in male prisoners. J. Forensic Sci. 54, 692–698. https://doi.org/10.1111/j.1556-4029.2009.01028.x.

Lanes, E.C., 2011. Are the “worst of the worst” self-injurious prisoners more likely to end up in long-term maximum-security administrative segregation? Int. J. Offender Ther. Comp. Criminol. 55, 1034–1050. https://doi.org/10.1177/0306624X10378494.

Marzano, L., Hawton, K., Rivlin, A., Smith, E.N., Piper, M., Fazel, S., 2016. Prevention of suicidal behavior in prisons. Crisis 37, 1–12. https://doi.org/10.1027/0227-5910/a000394.

Mohino Justes, S., Ortega-Monasterio, L., Planchat Teruel, L.M., Cuquerella Fuentes, A., Talón Navarro, T., Macho Vives, L.J., 2004. Discriminating deliberate self-harm (DSH) in young prison inmates through personality disorder. J. Forensic Sci. 49, 137–140.

Preti, A., Cascio, M.T., 2006. Prison suicides and self-harming behaviours in Italy, 1990-2002. Med. Sci. Law 46, 127–134. https://doi.org/10.1258/rsmmsl.46.2.127.

Rivlin, A., Hawton, K., Marzano, L., Fazel, S., 2013. Psychosocial characteristics and social networks of suicidal prisoners: towards a model of suicidal behaviour in detention. PLoS ONE 8 (7), e68944. https://doi.org/10.1371/journal.pone.0068944.

Sahlin, H., Kuja-Halkol, R., Bjureberg, J., Lichtenstein, P., Molero, Y., Rydell, M., et al., 2017. Association between deliberate self-harm and violent criminality. JAMA Psychiatry 74, 615–621. https://doi.org/10.1001/jamapsychiatry.2017.0338.

Smith, H.P., Kaminski, R.J., 2011. Self-injurious behaviors in state prisons: findings from a national survey. Crim. Justice Behav. 38, 26–41. https://doi.org/10.1177/0093854810385886.

Smith, H.P., Kaminski, R.J., 2010. Inmate self-injurious behaviors. Crim. Justice Behav 37, 81–96. https://doi.org/10.1177/0093854809348474.

Stekhoven, D.J., 2016. Nonparametric missing value imputation using random forest. R Packag. version 1.4.https://doi.org/10.1093/bioinformatics/btr597.

Stekhoven, D.J., Bühlmann, P., 2012. Missforest-Non-parametric missing value imputation for mixed-type data. Bioinformatics 28, 112–118. https://doi.org/10.1093/bioinformatics/btr597.

Vaughn, M.G., DeLisi, M., Beaver, K.M., Wright, J.P., 2009. Identifying latent classes of behavioral risk based on early childhood: manifestations of self-control. Youth Violence Juv. Justice. 7, 16–31. https://doi.org/10.1177/1541204008324911.

Vaughn, M.G., Salas-Wright, C.P., DeLisi, M., Maynard, B.R., 2014. Violence and externalizing behavior among youth in the United States: is there a severe 5%? Youth Violence Juv. Justice. 12, 3–21. https://doi.org/10.1177/1541204013478973.

Waljee, A.K., Mukherjee, A., Singal, A.G., Zhang, Y., Warren, J., Balis, U., et al., 2013. Comparison of imputation methods for missing laboratory data in medicine. BMJ Open. 1 (8), 3. https://doi.org/10.1136/bmjopen-2013-002847.

Webb, R.T., Antonsen, S., Carr, M.J., Appleby, L., Pedersen, C.B., Mok, P.L.H., 2017. Self-harm and violent criminality among young people who experienced trauma-related hospital admission during childhood: a Danish national cohort study. Lancet Public Health 2, e314–e322. https://doi.org/10.1016/S2468-2667(17)30094-4.

Zou, G., 2004. A modified Poisson regression approach to prospective studies with binary data. Am. J. Epidemiol. 159 (7), 702–706. https://doi.org/10.1093/aje/kwh090.