

Supplementary material

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Imputation of missing data

Missing data of fixed variables were handled by multivariate imputation by chained equations (1). The following imputation strategy was adopted for time varying variables: for a given incarceration and for a given variable 1) any period with a missing value takes the nearest non-missing value among the preceding periods, or failing that, among the following periods; 2) if the value is missing for the entire incarceration, then the value of the first period is estimated by multivariate imputation by chained equations and extrapolated to the entire incarceration.

Using multivariate imputation by chained equations, binary variables were imputed by logistic regression. Quantitative variables were imputed by predictive mean matching, which preserves non-linear relationships [1]. Categorical variables with more than two categories were imputed by multinomial regression. With these statistical models, missing data for each characteristic collected only at the start date of incarceration were imputed using the value at the start date of incarceration of all explanatory variables, as well as an incarceration censoring variable, length of follow-up and the suicide variable [2]. For time-dependent variables with missing data for the entire incarceration, the value of the first period, which is the value of the follow-up start date, was imputed from the same variables, plus the value of the other time-dependent variables at the follow-up start date.

The number of iterations required was determined by a graphical method [3] and corresponds to the minimum number of iterations at which the mean and variance of the imputed values for each characteristic 1) converged between the different imputed data sets; 2) remained stably within the same range of values. Four iterations were considered sufficient. The number of imputation needed was estimated according to the procedure proposed by von Hippel [4, 5]. The desired coefficient of variation was set at 5%. For each parameter, we used as the fraction of missing information the average, over 10 pilot analyses, of the upper limit of the 95% confidence interval of the fraction of missing information calculated over 50 imputations. The highest fraction of missing information, found for the personal housing variable, led to the retention of 40 imputations.

Survival analyses were performed on each of the 40 imputations. Wald tests and hazard ratio confidence intervals were pooled using the formulas given by Rubin [6]. Likelihood ratio tests and proportional hazards tests were pooled by the D2 method [7].

References

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Table A. Characteristics of studies using multivariate statistical models to assess risk factors of suicide among the general prison population

First author, year	Location	Period	Cases	Study design	Multivariate analysis model	Factors independently associated with suicide
Blaauw, 2005	Netherlands	1987-1998	95	Case-control study. Cases: all suicides that occurred in any penal institution validated by the first two authors. Controls: random sample from inmates in ten jails for adults	Forward stepwise logistic regression analysis	History of psychiatric care, age over 40, violent offence, homelessness, one prior incarceration, history of hard drug abuse
Bourgoin, 1993	France	1990-1992	179	Case-control study. Cases: all suicides occurring in prison Controls: random sample from all national prisoners	Forward stepwise logistic regression analysis	French nationality, high level of education, employed, no religion, offence against a relative, remand period, sentence over 3 years, the first two months of imprisonment
Duthé, 2013	France	2006-2009	353	Comprehensive national retrospective cohort study. Population: all adult male prisoners	Cox regression model including all covariables	Age over 30, disciplinary cell, hospitalization during follow-up, no visit from relatives during follow-up, remand period, homicide, rape, other sexual assault, other violent offence
Duthé, 2014	France	2006-2009	377	Comprehensive national retrospective cohort study. Population: any person under the responsibility of a prison director.	Cox regression model including all covariables	Disciplinary cell, hospitalization during follow-up, no visit from relatives during follow-up, remand period, homicide, rape, other sexual assault, other violent offence
Fruehwald, 2004	Austria	1975-1999	220	Case-control study. Cases: every suicide that occurred in a correctional institution. Controls: sample matched for age, gender, nationality, custodial institution, custodial status and time of admission	Forward stepwise unmatched logistic regression. Separate analyses were performed for pre-trial and sentenced prisoners, due to an imbalance of missing values.	Pre-trial group: single-cell accommodation, known suicide attempt, psychiatric medication, last offence highly violent. Sentenced group: psychiatric diagnosis, single cell accommodation, suicide threat, last offence highly violent, psychiatric medication
Humber, 2013	England and Wales	2005-2008	220	Case-control study. Cases: all suicides occurring in any prison. Controls: random sample matched for gender, age, establishment type and date of reception into prison.	Backward stepwise conditional logistic regression	History of self-harm, occupying a single cell, remand status, non-white ethnicity, previous mental health contact

Table B. Length of individual follow-up and length of prison stays, in months

	n	median	(Q1-Q3)	mean	(min-max)
Length of individual follow-up	358 522	4.8	(2.0 - 10.8)	8.7	(<0.1 - 48.0)
Length of prison stays	290 401 ^a	5.1	(2.3 - 11.5)	10.5	(<0.1 - 465.6)

^a *The calculation of the lengths of detention excludes right-censored prison stays*

Table C. Time dependant characteristics of the prisoners and associated suicide rates (n=358 522)

	PY ^a	(%)	Suicides	(%)	Suicide rate per 100 000 PY ^a	CI _{95%} ^b	p
Criminal category							<0.001
<i>Pre-trial incarceration</i>	78 753.4	(30.9)	235	(53.0)	298	[260 - 337]	
<i>Post-sentence incarceration</i>	175 967.6	(69.1)	208	(47.0)	118	[102 - 134]	
<i>Missing</i>	5 197.4		6				
Stage of incarceration							<0.001
<i><1 week</i>	5 278.0	(2.0)	51	(11.4)	966	[701 - 1231]	
<i>1 week to 6 months</i>	93 801.4	(36.1)	188	(41.9)	200	[172 - 229]	
<i>≥ 6 months</i>	160 839.0	(61.9)	210	(46.8)	131	[113 - 148]	
Type of facility							<0.001
<i>PPSS^c</i>	174 185.8	(68.4)	340	(78.5)	195	[174 - 216]	
<i>SSPLS^d</i>	68 029.2	(26.7)	78	(18.0)	115	[89 - 140]	
<i>HSPLS^e</i>	6 380.9	(2.5)	9	(2.1)	141	[49 - 233]	
<i>Other</i>	6 089.4	(2.4)	6	(1.4)	99	[20 - 177]	
<i>Missing</i>	5 233.1		16				
Prison size							0.278
<i>≤ 500</i>	88 261.1	(34.2)	150	(33.8)	170	[143 - 197]	
<i>500-1000</i>	121 998.8	(47.3)	209	(47.1)	171	[148 - 195]	
<i>>1000</i>	47 652.3	(18.5)	85	(19.1)	178	[140 - 216]	
<i>Missing</i>	2 006.2		5				
Prison overcrowding							<0.001
<i>No</i>	87 265.3	(34.3)	105	(24.1)	120	[97 - 143]	
<i>Yes</i>	167 244.2	(65.7)	330	(75.9)	197	[176 - 219]	
<i>Missing</i>	5 408.8		14				

^a Person-years; ^b 95% confidence interval; ^c Prison for pre-trial incarceration and short sentences; ^d Standard security prison for long sentences; ^e High security prison for long sentences

Note: the percentages of person-years are representative of the incarcerated population at a time "t"

Table D. Individual trajectories by criminal category and type of facility

	All (n = 358 522)	UI (n = 234 836)	ICL (n = 55 565)	ICR (n = 57 631)	LRCI (n = 10 490)
Criminal category					
<i>Pre-trial then post-sentence</i>	38.7%	44.7%	12.2%	43.9%	25.9%
<i>Post-sentence incarceration only</i>	29.2%	23.3%	69.4%	9.0%	46.7%
<i>Pre-trial incarceration only</i>	24.0%	25.6%	11.4%	34.2%	3.8%
<i>Other trajectories</i>	8.0%	6.4%	7.0%	12.9%	23.6%
Type of facility					
<i>PPSS only</i>	77.5%	86.4%	54.9%	73.2%	10.0%
<i>PPSS then SSPLS</i>	8.7%	5.8%	8.3%	18.1%	27.5%
<i>Other trajectories</i>	13.8%	7.8%	36.9%	8.7%	62.6%

ICL: incarcerations censored only on the left; ICR: incarcerations censored only on the right; LRCI: left and right censored incarcerations; PPSS: Prison for pre-trial incarceration and short sentences; SSPLS: Standard security prison for long sentences; UI: uncensored incarcerations

Table E. Univariate survival analysis (n = 358 522)

	HR ^a	IC _{95%} ^b	p	%VI ^c
Age (years)			<0.001	
13-29	Ref.			
30-39	1.7	[1.3 - 2.1]	<0.001	<0.1
40-99	2.7	[2.1 - 3.3]	<0.001	<0.1
Women (vs men)	1.3	[0.8 - 2.0]	0.157	0
Nationality			0.007	
African countries	Ref.			
France	1.6	[1.1 - 2.3]	0.004	0.2
Other european countries	2.1	[1.3 - 3.3]	<0.001	0.2
Other continents	1.4	[0.8 - 2.6]	0.144	0.3
High school diploma	1.6	[1.2 - 2.1]	<0.001	29.7
Occupational status			0.732	
Other occupation	Ref.			
Hand worker	1.0	[0.8 - 1.4]	0.412	20.7
Inactive	1.1	[0.8 - 1.5]	0.263	19.8
Personal housing	1.5	[1.2 - 1.9]	<0.001	32.4
Marital status			<0.001	
Single	Ref.			
Lives with a partner (including married)	1.2	[1.0 - 1.5]	0.060	24.5
Separated (including divorced and widowed)	2.6	[1.9 - 3.6]	<0.001	24.8
Children	1.5	[1.2 - 1.9]	<0.001	25.9
Criminal court	1.7	[1.4 - 2.0]	<0.001	0.5
Main offence			<0.001	
Other offence	Ref.			
Homicide	2.5	[2.0 - 3.2]	<0.001	0.8
Rape and sexual assault	2.1	[1.6 - 2.7]	<0.001	0.6
Physical assault	1.6	[1.2 - 2.1]	<0.001	1.7
Pre-trial incarceration	2.5	[2.0 - 3.0]	<0.001	0.6
Stage of incarceration			<0.001	
≥ 6 months	Ref.			
<1 week	7.4	[5.5 - 10.1]	<0.001	0
1 week to 6 months	1.5	[1.3 - 1.9]	<0.001	0
Type of facility			<0.001	
SSPLS ^d	Ref.			
PPSS ^e	1.7	[1.4 - 2.2]	<0.001	0.3
HSPLS ^f	1.2	[0.6 - 2.4]	0.282	<0.1
Other	0.9	[0.4 - 2.0]	0.350	0.6
Prison size ^g	1.0	[1.0 - 1.0]	0.278	0.8
Overcrowding	1.7	[1.3 - 2.1]	<0.001	1.5

^a Hazard ratio; ^b 95% confidence interval; ^c Percentage of variance attributable to imputation of missing data; ^d Standard security prison for long sentences; ^e Prison for pre-trial incarceration and short sentences; ^f High security prison for long sentence; ^g HR associated with an increase of 100 prisoners

Table F. Interactions, trivariate survival analysis (n = 358 522)

	Stage of incarceration						p
	<1 week		1 week to 6 months		≥ 6 months		
	HR ^a	CI _{95%} ^b	HR ^a	CI _{95%} ^b	HR ^a	CI _{95%} ^b	
Model 2a : interaction between stage of incarceration and main offense category							<0.001
Relationship between suicide and stage of incarceration, according to offence							
<i>Other offence</i>	5.1	[3.0 - 8.7]	1.6	[1.2 - 2.2]	Ref.		
<i>Homicide</i>	36.6	[20.2 - 66.4]	2.7	[1.7 - 4.4]	Ref.		
<i>Rape and sexual assault</i>	29.7	[14.8 - 59.3]	4.7	[3.0 - 7.5]	Ref.		
<i>Physical assault</i>	6.3	[2.9 - 13.5]	1.3	[0.8 - 2.1]	Ref.		
Relationship between suicide and offence, according to stage of incarceration							
<i>Other offence</i>	Ref.		Ref.		Ref.		
<i>Homicide</i>	17.8	[8.5 - 37.1]	4.2	[2.7 - 6.7]	2.5	[1.8 - 3.5]	
<i>Rape and sexual assault</i>	9.2	[4.2 - 20.2]	4.7	[3.2 - 6.9]	1.6	[1.1 - 2.3]	
<i>Physical assault</i>	2.1	[0.9 - 5.0]	1.3	[0.9 - 2.0]	1.7	[1.1 - 2.7]	
Model 3a : interaction between stage of incarceration and overcrowding							0.037
Relationship between suicide and stage of incarceration, according to overcrowding							
<i>No overcrowding</i>	10.7	[4.3 - 26.5]	2.3	[1.5 - 3.7]	Ref.		
<i>Overcrowding</i>	6.0	[4.3 - 8.4]	1.2	[1.0 - 1.5]	Ref.		
Relationship between suicide and overcrowding, according to stage of incarceration							
<i>No overcrowding</i>	Ref.		Ref.		Ref.		
<i>Overcrowding</i>	0.9	[0.4 - 2.3]	0.9	[0.6 - 1.3]	1.6	[1.2 - 2.2]	
Model 4a : interaction between stage of incarceration and gender							0.008
Relationship between suicide and stage of incarceration, according to gender							
<i>Men</i>	7.9	[5.8 - 10.8]	1.6	[1.3 - 2.0]	Ref.		
<i>Women</i>	1.5	[0.2 - 11.5]	0.4	[0.1 - 1.1]	Ref.		
Relationship between suicide and gender, according to stage of incarceration							
<i>Men</i>	Ref.		Ref.		Ref.		
<i>Women</i>	0.4	[0.1 - 3.1]	0.5	[0.2 - 1.4]	2.3	[1.3 - 3.8]	

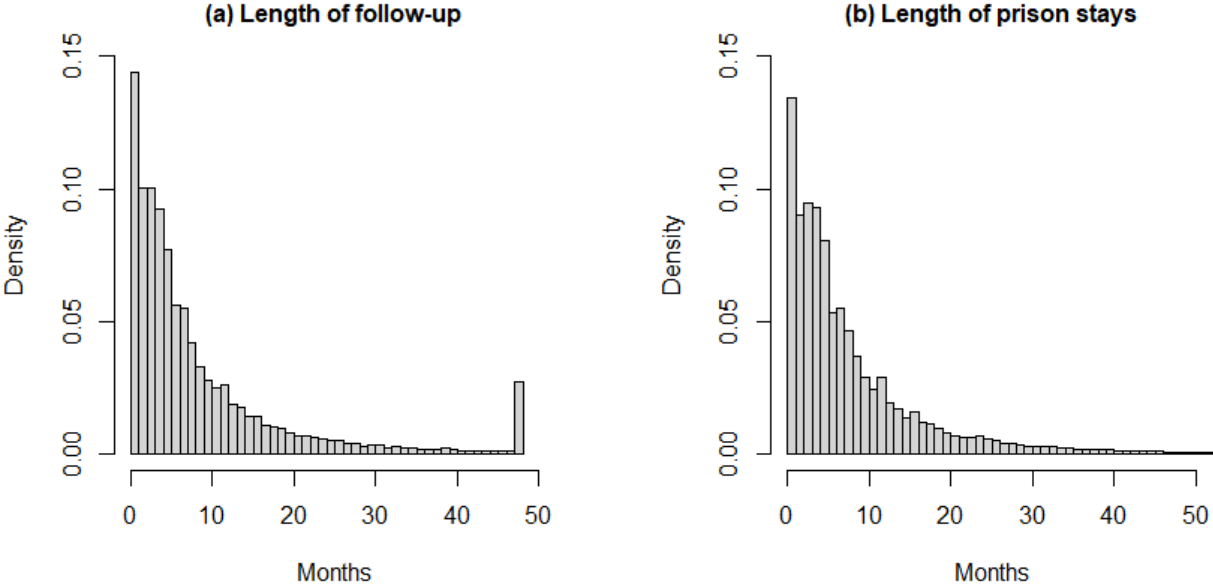
^a Hazard ratio; ^b 95% confidence interval

Table G. Interactions, multivariate survival analysis^a (n=358 522)

	Stage of incarceration						p
	<1 week		1 week to 6 months		≥ 6 months		
	HR ^b	CI _{95%} ^c	HR ^b	CI _{95%} ^c	HR ^b	CI _{95%} ^c	
Model 2b : interaction between stage of incarceration and main offense category							<0.001
Relationship between suicide and stage of incarceration, according to offence							
<i>Other offence</i>	3.8	[2.2 - 6.5]	1.5	[1.1 - 2]	Ref.		
<i>Homicide</i>	28.0	[15.2 - 51.6]	2.1	[1.3 - 3.5]	Ref.		
<i>Rape and sexual assault</i>	21.9	[10.8 - 44.6]	3.9	[2.4 - 6.2]	Ref.		
<i>Physical assault</i>	4.0	[1.8 - 8.8]	1.1	[0.6 - 1.8]	Ref.		
Relationship between suicide and offence, according to stage of incarceration							
<i>Other offence</i>	Ref.		Ref.		Ref.		
<i>Homicide</i>	15.8	[7.3 - 34.2]	3.1	[1.8 - 5.2]	2.1	[1.4 - 3.2]	
<i>Rape and sexual assault</i>	7.0	[3.1 - 15.6]	3.2	[2.1 - 4.9]	1.2	[0.8 - 1.9]	
<i>Physical assault</i>	1.9	[0.8 - 4.6]	1.3	[0.9 - 2.0]	1.8	[1.2 - 2.8]	
Model 3b : interaction between stage of incarceration and overcrowding							0.029
Relationship between suicide and stage of incarceration, according to overcrowding							
<i>No overcrowding</i>	14.5	[5.5 - 38.6]	3.5	[2.1 - 5.8]	Ref.		
<i>Overcrowding</i>	7.0	[4.9 - 10.0]	1.7	[1.3 - 2.2]	Ref.		
Relationship between suicide and overcrowding, according to stage of incarceration							
<i>No overcrowding</i>	Ref.		Ref.		Ref.		
<i>Overcrowding</i>	0.8	[0.3 - 2.1]	0.8	[0.5 - 1.3]	1.8	[1.1 - 2.7]	
Model 4b : interaction between stage of incarceration and gender							0.025
Relationship between suicide and stage of incarceration, according to gender							
<i>Men</i>	8.1	[5.7 - 11.4]	2.0	[1.6 - 2.5]	Ref.		
<i>Women</i>	2.0	[0.3 - 15.0]	0.5	[0.2 - 1.6]	Ref.		
Relationship between suicide and gender, according to stage of incarceration							
<i>Men</i>	Ref.		Ref.		Ref.		
<i>Women</i>	0.4	[0.1 - 2.8]	0.4	[0.2 - 1.2]	1.6	[0.9 - 2.7]	

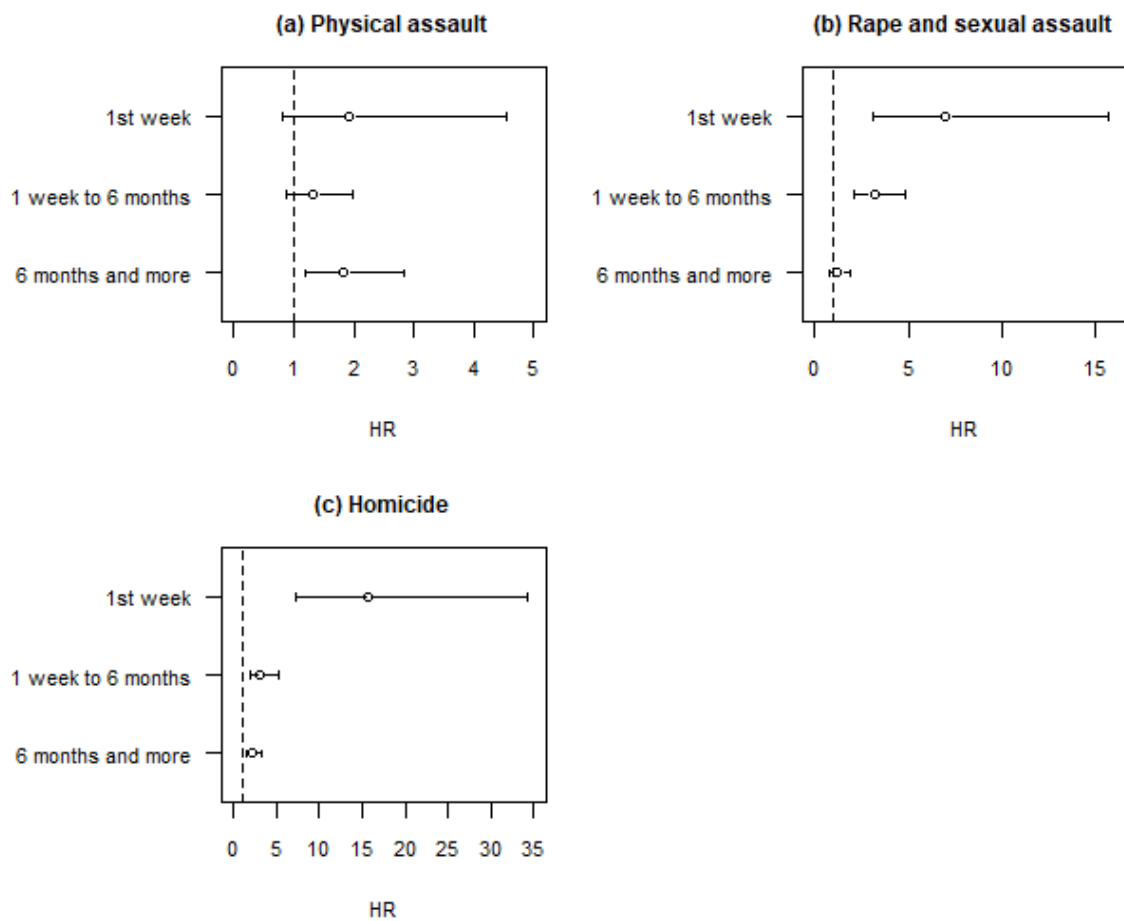
^a Interactions are adjusted on all covariates of the M1 model; ^b Hazard ratio; ^c 95% confidence interval

Figure A. Length of individual follow-up and length of prison stays



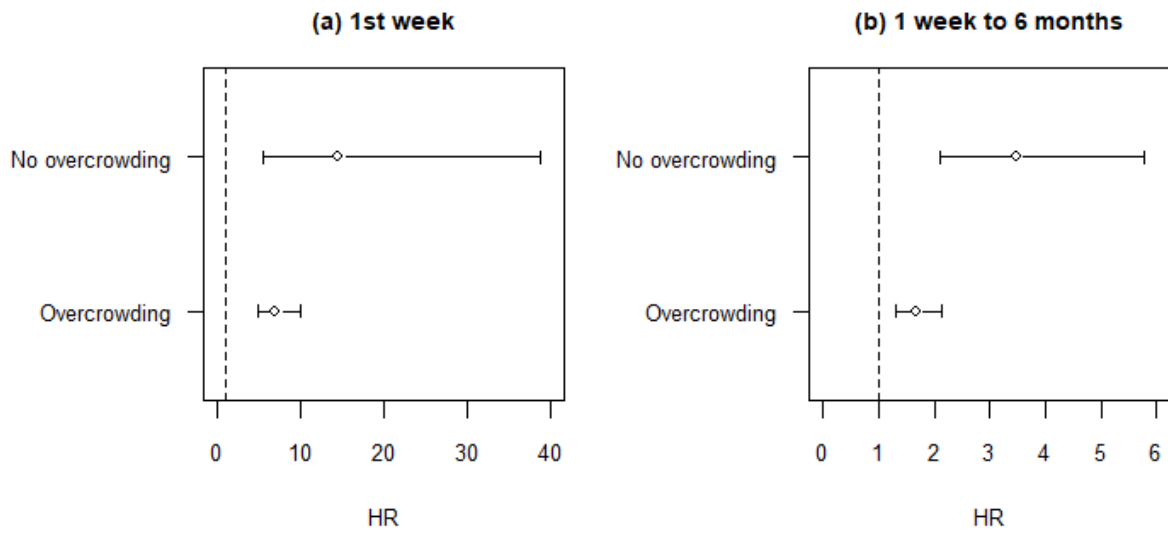
Note: The calculation of lengths of prison stays excludes right-censored prison stays. For individual follow-up times, the higher bar at 48 months corresponds to all left and right censored prison stays. The maximum length of stay in prison is 456.6 months (38 years), but the corresponding histogram does not show the stays in prison of more than 50 months because they are few.

Figure B. Relationship between suicide and offence according to stage of incarceration, multivariate analysis (n = 358 522)



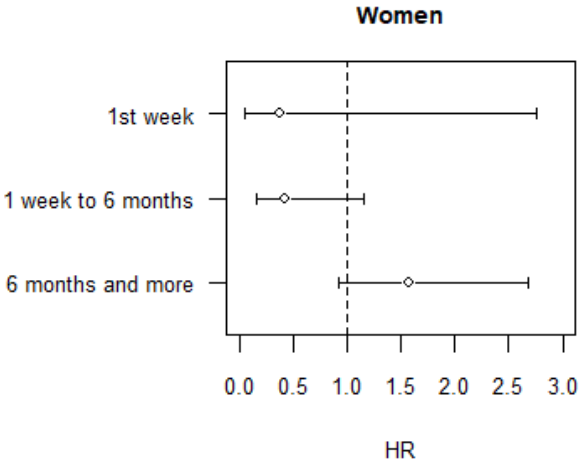
Note: the reference group for all Hazard Ratios is "other offence"

Figure C. Relationship between suicide and stage of incarceration according to overcrowding, multivariate analysis (n = 358 522)



Note: the reference group for all Hazard Ratios is the stage of incarceration “ ≥ 6 months”

Figure D. Relationship between suicide and gender according to stage of incarceration, multivariate analysis (n = 358 522)



Note: the reference group for all Hazard Ratios is men