

Supplementary Material

Article Title: History of Concussion and Risk of Severe Maternal Mental Illness: A Population-Based Cohort Study

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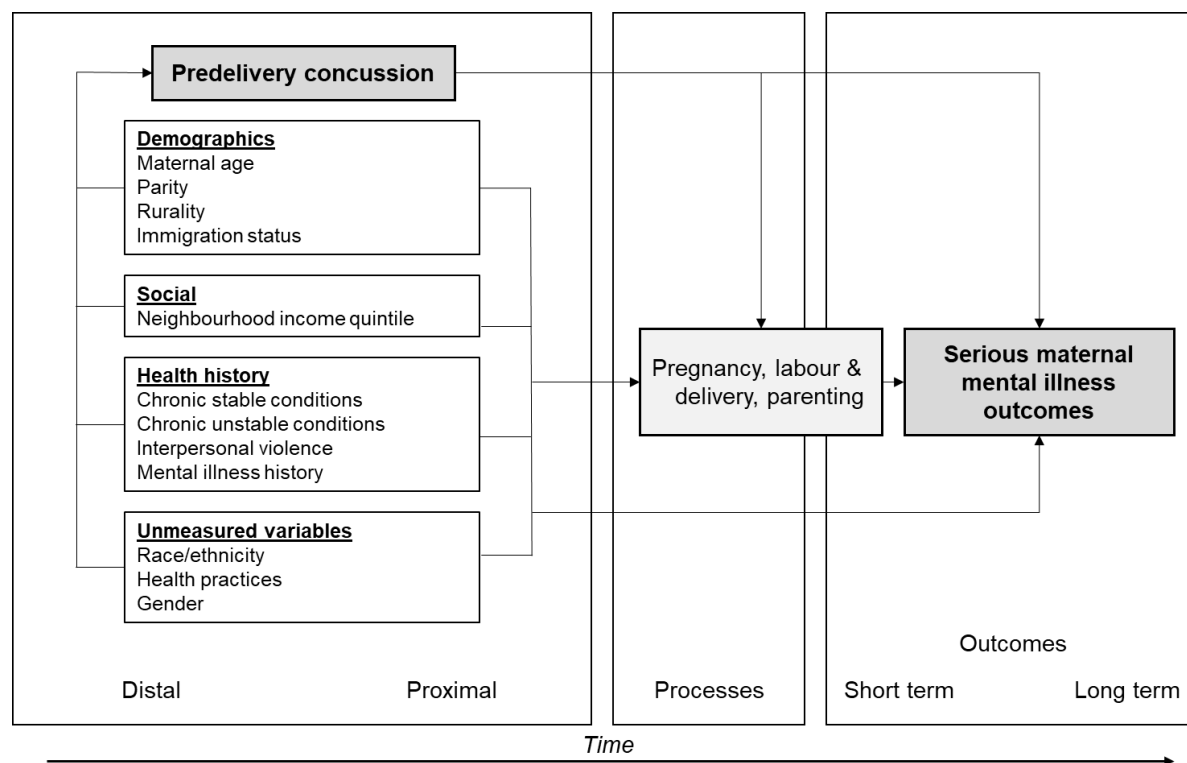
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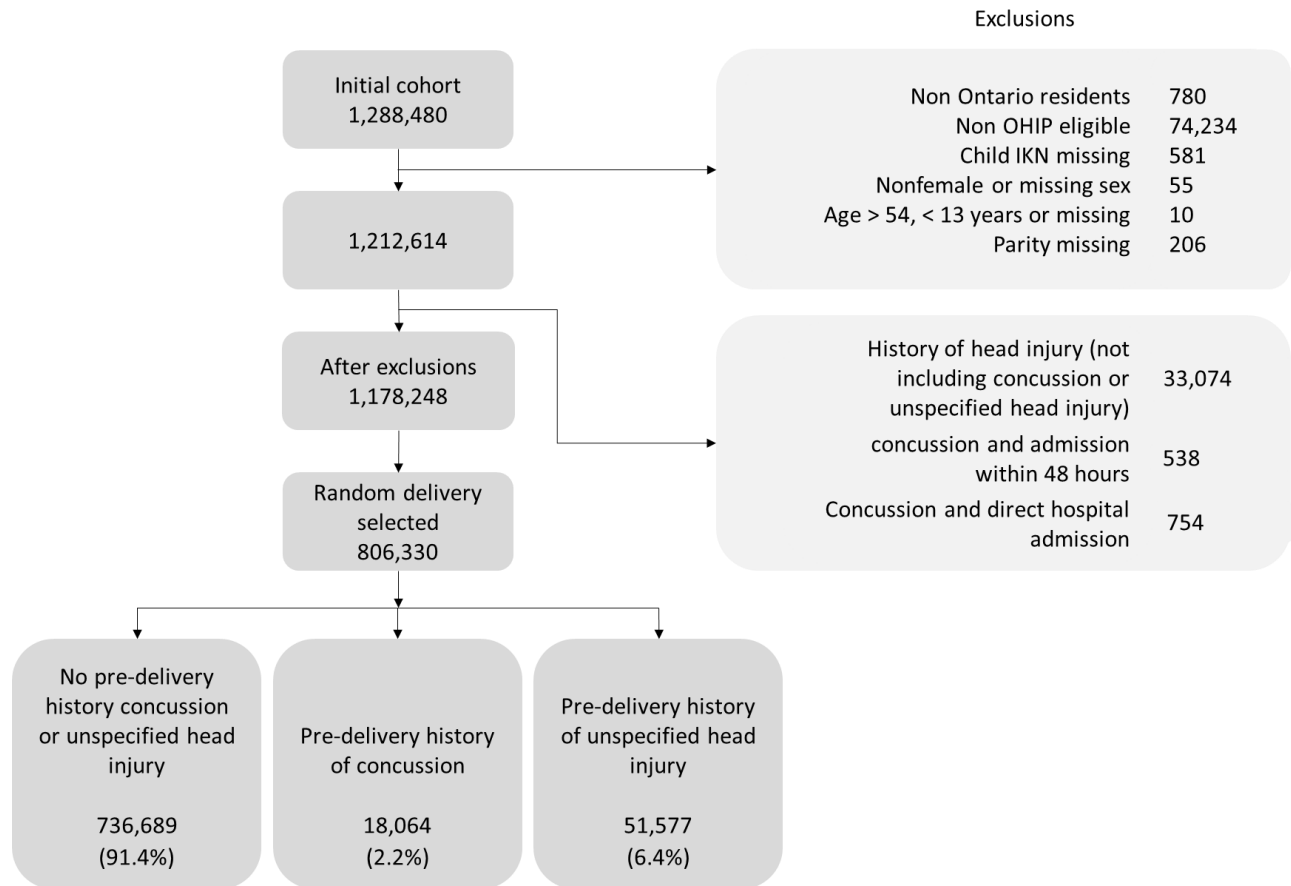
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Supplementary Figure 1: Conceptual model

Supplementary Figure 2: Cohort creation flow diagram

This figure displays the creation of the final cohort after exclusions and selection of one random delivery per mother. The right of the figure displays the exclusion criteria including the number excluded per criterion. The final cohort is displayed in the three boxes in the bottom left of the figure: those without a pre-delivery history of concussion or unspecified head injury, those with a pre-delivery history of concussion only, and those with a pre-delivery history of unspecified head injury.



Supplementary Table 1: Health administrative databases and descriptions.

Databases	Description	Variables for this study	Availability
Canadian Institute for Health Information Discharge Abstract Database (CIHI-DAD)	Contains information on hospital admissions, including clinical, demographic, and administrative information	Baseline characteristics: stable and unstable chronic conditions, history of hospital admission for mental illness	April 1988 onward
		Pregnancy characteristics: hospital admissions for pregnancy-induced hypertension, gestational diabetes	
		Child characteristics: NICU admission	
		Outcome: hospital admissions for mental illness	
		Sensitivity analysis: concussion or TBI following delivery	
Mother-baby dataset (MOMBABY)	Links maternal and child CIHI-DAD records	Delivery admission information: delivery date, maternal age, parity, mode of delivery, gestational age at delivery date, child sex, birthweight, small for gestational age	April 1988 onward
Census	Contains information on population size, neighbourhood income quintile which is linked to the RPDB	Baseline characteristics: neighbourhood income quintile, rural residence	1991, 1996, 2001, 2006, 2011, 2016
Immigration, Refugees and Citizenship Canada Permanent Residents Database (IRCC)	Contains information from immigration application records	Baseline characteristics: refugee, non-refugee immigrant, and long-term resident status	January 1985 onward
National Ambulatory Care Reporting System (NACRS)	Contains information on emergency department visits, including clinical, demographic, and administrative information	Baseline characteristics: stable and unstable chronic conditions, history of assault, history of ED visit for mental illness	2002 onward
		Pregnancy characteristics: ED visits for pregnancy-induced hypertension, gestational diabetes	
		Exposure: ED visit for concussion	
		Outcome: ED visits for mental illness, self-harm	
		Sensitivity analysis: concussion or TBI following delivery	
Ontario Health Insurance Plan (OHIP) database	Contains information from claims paid for by the Ontario Health Insurance Plan, including outpatient physician visits.	Baseline characteristics: stable and unstable chronic conditions, history of outpatient visit for mental illness	July 1991 onwards
		Pregnancy characteristics: outpatient visits for pregnancy-induced hypertension, gestational diabetes	
		Exposure: outpatient visits for concussion, ED visits for concussion prior to 2002 using OHIP macro for ED visits.	
		Sensitivity analysis: concussion or TBI following delivery	
		Censoring: Loss of OHIP eligibility	
Ontario Mental Health Reporting System	Contains information on hospital admissions for	Baseline characteristics: adult hospital admissions for mental illness	October 2005 onward

Databases	Description	Variables for this study	Availability
(OMHRS)	adults to mental health designated beds	Outcome: adult hospital admissions for mental illness	
Ontario Registrar General Database (ORGD)	Contains information on all deaths registered in Ontario	Outcome: Death by suicide	December 1990 onward
		Censoring: Death not by suicide	
Registered Persons Database (RPDB)	Contains demographic information which is linked to Census data	Baseline characteristics: Postal code at delivery for ascertainment of neighbourhood income quintile, rural residence	April 1991 onward

Abbreviations: NICU: neonatal intensive care unit, TBI: traumatic brain injury, ED: emergency department.

Supplementary Table 2: Diagnostic codes for severe maternal mental illness.

Outcome	ICD-10 codes (CIHI-DAD/NACRS)	DSM-IV codes (OMHRS)	DSM-V codes (OMHRS post 2016/2017)
Psychiatric emergency department visit or hospitalization	F06.0-F06.4, F07.0, F10-21, F22-F29, F30.x, F31.x, F32, F33, F34.1, F34.8, F34.9, F38, F39, F32.x, F33.x, F34.0, F34.1, F40-F43, F45.2, F53.0, F53.1, F55, F60-F63, F68, F69, F93.1, F93.0-F93.2, F94.0-F94.2	291.x (excl. 291.82), 292.x (excl. 292.85), 293.83, 295.x, 296.0x, 296.2x, 296.3x, 296.4x, 296.5x, 296.6x, 296.7, 296.80, 297.x, 298.x, 300, 300.0x, 300.2x, 300.3x, 300.4x, 301.0, 301.13, 301.20, 301.22, 301.4, 301.50, 301.6, 301.7, 301.81, 301.82, 301.83, 301.9, 303.x, 304.x, 305.x, 308.3x, 309.0x, 309.24, 309.28, 309.3x, 309.4x, 309.8x, 309.9x, 311.x, PROVDX = 4 - 7, 15	291.x, 292.x, 293.81/82, 293.84, 295.x, 296.0x, 296.2x, 296.3x, 296.4x, 296.5x, 296.6x, 296.7x, 296.8x, 296.9x, 297.x, 298.x, 300, 300.0x, 300.2x, 300.3x, 300.4x, 300.7x, 301, 301.0x, 301.13, 301.2x, 301.4x, 301.5x, 301.6x, 301.7x, 301.81-3, 301.89, 301.9x, 303.x, 304.x, 305.x, 308.3x, 309, 309.0x, 309.21, 309.24, 309.28, 309.3x, 309.4x, 309.81, 309.89, 309.9x, 310.1, 311.x, 312.31, 312.39, 313.23, 313.89, 625.4x, PROVDX = 2, 3, 4, 5 – 7, 16, 18
Self-harm	DX10CODE2-10 = X60-X84, Y10-Y19, Y28 (with or without a psychiatric diagnosis)		
Suicide	Cause of death = suicide in ORGD		

Abbreviations: ICD: International Classification of Disease, CIHI-DAD: Canadian Institute for Health Information Discharge Abstract Database, NACRS: National Ambulatory Care Reporting System, DSM: Diagnostic and Statistical Manual of Mental Disorders, OMHRS: Ontario Mental Health Reporting System, ED: emergency department, ORGD: Ontario Registrar General Database.

Supplementary Table 3: Diagnostic codes for each psychiatric diagnosis, recorded in emergency department visits and hospital admissions.

Outcome	ICD-10 codes (CIHI-DAD/NACRS)	DSM-IV codes (OMHRS)	DSM-V codes (OMHRS post 2016/2017)
Psychotic disorders	F06.0-F06.2, F20, F22-F29, F53.1	295.x, 297.x, 298.x. Provisional=5	293.81/82, 295.x, 297.x, 298.x. Provisional=2
Depressive and other mood disorders	F06.3, F30.x, F31.x, F32, F33, F34.1, F34.8, F34.9, F38, F39, F53.0, F52.x, F33.x, F34.0, F34.1, F53.8 and 53.9 (was 53.0)	293.83, 296.0x, 296.2x, 296.3x, 296.4x, 296.5x, 296.6x, 296.7, 296.80, 300.4x, 301.13, 311.x. Provisional=6	296.0x, 296.2x, 296.3x, 296.4x, 296.5x, 296.6x, 296.7x, 296.8x, 296.9x, 300.4x, 301.13, 311.x, 625.4x. Provisional=3 or 4
Anxiety and related disorders	F06.4, F40-F43, F45.2, F63.3, F93.1, F93.0-F93.2, F94.0-F94.2	300, 300.0x, 300.2x, 300.3x, 308.3x, 309.0x, 309.24, 309.28, 309.3x, 309.4x, 309.8x, 309.9x. Provisional=7, 15	293.84, 300, 300.0x, 300.2x, 300.3x, 300.7x, 308.3x, 309, 309.0x, 309.21, 309.24, 309.28, 309.3x, 309.4x, 309.81, 309.89, 309.9x, 312.39, 313.23, 313.89, 698.4x. Provisional=5-7
Alcohol and substance use disorders	F10-19, F55, F63	291.x (excl. 291.82), 292.x (excl. 292.85), 303.x, 304.x, 305.x. Provisional=4	291.x, 292.x, 303.x, 304.x, 305.x, 312.31. Provisional=16

Abbreviations: ICD: International Classification of Disease, CIHI-DAD: Canadian Institute for Health Information Discharge Abstract Database, NACRS: National Ambulatory Care Reporting System, DSM: Diagnostic and Statistical Manual of Mental Disorders, OMHRS: Ontario Mental Health Reporting System, ne: not equal to, ORGD: Ontario Registrar General Database.

Supplementary Table 4: Unadjusted and adjusted associations between a history of concussion and severe maternal mental illness, by proximity of concussion health care encounter.

Stratum	History of concussion	Number with outcome	Incidence per 1,000 person years (95% CI)	HR (95% CI)	aHR (95% CI)
Total cohort	No (N = 736,689)	49,928	7.9 (7.9-8.0)	1.00 (Referent)	1.00 (Referent)
	Yes > 5 years (N = 12,955)	1,325	13.0 (12.3-13.7)	1.61 (1.53-1.70)	1.22 (1.15-1.28)
	Yes 2-5 years (N = 2,718)	370	18.5 (16.7-20.5)	2.29(2.06-2.53)	1.30 (1.17-1.44)
	Yes < 2 years (N = 2,391)	338	20.5 (18.4-22.8)	2.50 (2.25-2.79)	1.37 (1.23-1.52)
No mental illness history	No (N = 511,550)	21,732	4.9 (4.9-5.0)	1.00 (Referent)	1.00 (Referent)
	Yes > 5 years (N = 7,952)	479	7.5 (6.9-8.2)	1.51 (1.38-1.66)	1.25 (1.14-1.37)
	Yes 2-5 years (N = 1,493)	112	9.9 (8.2-11.9)	2.00 (1.66-2.41)	1.51 (1.25-1.83)
	Yes < 2 years (N = 1,267)	97	10.6 (8.7-12.9)	2.13 (1.75-2.60)	1.64 (1.34-2.00)
Outpatient care for mental illness history	No (N = 188,307)	16,450	9.9 (9.8-10.1)	1.00 (Referent)	1.00 (Referent)
	Yes > 5 years (N = 3,855)	434	13.8 (12.6-15.2)	1.37 (1.25-1.51)	1.22 (1.11-1.34)
	Yes 2-5 years (N = 798)	103	16.9 (13.9-20.4)	1.67 (1.37-2.02)	1.40 (1.15-1.70)
	Yes < 2 years (N = 758)	105	19.9 (16.4-24.0)	1.94 (1.60-2.35)	1.59 (1.31-1.93)
Acute care for mental illness history	No (N = 36,832)	11,746	46.3 (45.5-47.1)	1.00 (Referent)	1.00 (Referent)
	Yes > 5 years (N = 1,148)	412	57.4 (52.1-63.2)	1.21 (1.09-1.33)	1.15 (1.04-1.27)
	Yes 2-5 years (N = 427)	155	59.6 (50.8-69.6)	1.24 (1.05-1.45)	1.13 (0.96-1.32)
	Yes < 2 years (N = 366)	136	65.9 (55.5-77.7)	1.33 (1.13-1.58)	1.15 (0.97-1.36)

HR adjusted for: maternal age at delivery, parity, neighbourhood income quintile, rural residence, immigration status, stable and unstable chronic conditions, history of assault, and history of mental illness (in unstratified models).

Abbreviations: HR: hazard ratio, aHR: adjusted hazard ratio, CI: confidence interval.

Supplementary Table 5: Unadjusted and adjusted associations between a history of concussion and severe maternal mental illness, with restricted 5-year concussion lookback period.

Stratum	History of concussion in pregnancy or the 5 years before conception	Number with outcome	Incidence per 1,000 person years (95% CI)	HR (95% CI)	aHR (95% CI)
Total cohort	No (N = 749,644)	51,253	8.0 (7.9-8.1)	1.00 (Referent)	1.00 (Referent)
	Yes (N = 5,109)	708	19.4 (18.1-20.9)	2.36 (2.19-2.54)	1.33 (1.23-1.43)
No mental illness history	No (N = 519,502)	22,211	5.0 (4.9-5.0)	1.00 (Referent)	1.00 (Referent)
	Yes (N = 2,760)	209	10.3 (8.9-11.7)	2.04 (1.78-2.34)	1.56 (1.36-1.79)
Outpatient care for mental illness history	No (N = 192,162)	16,884	10.0 (9.9-10.2)	1.00 (Referent)	1.00 (Referent)
	Yes (N = 1,556)	208	18.3 (15.9-20.9)	1.78 (1.55-2.04)	1.48 (1.29-1.70)
Acute care for mental illness history	No (N = 37,980)	12,158	46.6 (45.8-47.4)	1.00 (Referent)	1.00 (Referent)
	Yes (N = 793)	291	62.4 (55.5-69.9)	1.27 (1.13-1.43)	1.13 (1.01-1.28)

HR adjusted for: maternal age at delivery, parity, neighbourhood income quintile, rural residence, immigration status, stable and unstable chronic conditions, history of assault, and history of mental illness (in unstratified models).

Abbreviations: HR: hazard ratio, aHR: adjusted hazard ratio, CI: confidence interval.

Supplementary Table 6: Unadjusted and adjusted associations between a history of concussion or unspecified head injury and severe maternal mental illness.

Stratum	History of concussion or unspecified head injury	Number with outcome	Incidence per 1,000 person years (95% CI)	HR (95% CI)	aHR (95% CI)
Total cohort	No (N =736,689)	49,928	7.9 (7.9-8.0)	1.00 (Referent)	1.00 (Referent)
	Concussion only (N = 18,064)	2,033	14.7 (14.0-15.3)	1.82 (1.74-1.90)	1.25 (1.20-1.31)
	Concussion or unspecified head injury (N = 69,641)	10,025	19.1 (18.7-19.4)	2.36 (2.31-2.41)	1.34 (1.31-1.37)
No mental illness history	No (N =511,550)	21,732	4.9 (4.9-5.0)	1.00 (Referent)	1.00 (Referent)
	Concussion only (N = 10,712)	688	8.2 (7.6-8.8)	1.65 (1.53-1.78)	1.33 (1.23-1.44)
	Concussion or unspecified head injury (N = 39,412)	3,173	10.3 (9.9-10.7)	2.07 (1.99-2.15)	1.46 (1.40-1.52)
Outpatient care for mental illness history	No (N =188,307)	16,450	9.9 (9.8-10.1)	1.00 (Referent)	1.00 (Referent)
	Concussion only (N = 5,411)	642	15.0 (13.9-16.2)	1.48 (1.37-1.60)	1.30 (1.20-1.40)
	Concussion or unspecified head injury (N = 20,322)	2,849	18.0 (17.3-18.7)	1.77 (1.71-1.85)	1.39 (1.33-1.45)
Acute care for mental illness history	No (N =36,832)	11,746	46.3 (45.5-47.1)	1.00 (Referent)	1.00 (Referent)
	Concussion only (N = 1,941)	703	59.4 (55.1-63.9)	1.24 (1.15-1.33)	1.14 (1.06-1.24)
	Concussion or unspecified head injury (N = 9,907)	4,003	67.3 (65.3-69.4)	1.40 (1.35-1.45)	1.21 (1.16-1.25)

HR adjusted for: maternal age at delivery, parity, neighbourhood income quintile, rural residence, immigration status, stable and unstable chronic conditions, history of assault, and history of mental illness (in unstratified models).

Abbreviations: HR: hazard ratio, aHR: adjusted hazard ratio, CI: confidence interval.

Supplementary Table 7: Unadjusted and adjusted associations between a history of concussion and severe maternal mental illness, after excluding those with concussion or TBI after delivery.

Stratum	History of concussion	Number with outcome	Incidence per 1,000 person years (95% CI)	HR (95% CI)	aHR (95% CI)
Total cohort	No (N = 700,718)	46,588	7.8 (7.7-7.9)	1.00 (Referent)	1.00 (Referent)
	Yes (N = 16,246)	1,839	14.8 (14.1-15.5)	1.85 (1.76-1.94)	1.27 (1.21-1.33)
No mental illness history	No (N = 490,009)	20,357	4.9 (4.8-4.9)	1.00 (Referent)	1.00 (Referent)
	Yes (N = 9,858)	617	8.1 (7.5-8.7)	1.64 (1.52-1.78)	1.33 (1.23-1.44)
Outpatient care for mental illness history	No (N = 176,895)	15,296	9.9 (9.8-10.1)	1.00 (Referent)	1.00 (Referent)
	Yes (N = 4,864)	581	15.3 (14.1-16.6)	1.51 (1.39-1.64)	1.32 (1.21-1.43)
Acute care for mental illness history	No (N = 33,814)	10,935	47.8 (16.9-48.7)	1.00 (Referent)	1.00 (Referent)
	Yes (N = 1,704)	641	63.5 (58.7-68.5)	1.27 (1.18-1.38)	1.17 (1.08-1.27)

HR adjusted for: maternal age at delivery, parity, neighbourhood income quintile, rural residence, immigration status, stable and unstable chronic conditions, history of assault, and history of mental illness (in unstratified models).

Abbreviations: HR: hazard ratio, aHR: adjusted hazard ratio, CI: confidence interval, TBI: traumatic brain injury.

Supplementary Table 8: Unadjusted and adjusted associations between a history of concussion and severe maternal mental illness, when ending follow-up prior to the COVID-19 pandemic.

Stratum	History of concussion	Number with outcome	Incidence per 1,000 person years (95% CI)	HR (95% CI)	aHR (95% CI)
Total cohort	No (N = 736,689)	45,885	8.2 (8.1-8.3)	1.00 (Referent)	1.00 (Referent)
	Yes (N = 18,064)	1,868	15.3 (14.6-16.0)	1.84 (1.76-1.93)	1.26 (1.20-1.32)
No history of mental illness	No (N = 511,550)	19,673	5.0 (5.0-5.1)	1.00 (Referent)	1.00 (Referent)
	Yes (N = 10,712)	619	8.4 (7.8-9.1)	1.66 (1.53-1.80)	1.33 (1.23-1.45)
History of outpatient care for mental illness	No (N = 188,307)	15,186	10.3 (10.1-10.4)	1.00 (Referent)	1.00 (Referent)
	Yes (N = 5,411)	589	15.6 (14.3-16.9)	1.50 (1.38-1.63)	1.30 (1.20-1.42)
History of acute care for mental illness	No (N = 36,832)	11,026	48.3(47.4-49.2)	1.00 (Referent)	1.00 (Referent)
	Yes (N = 1,941)	660	62.4(57.8-67.4)	1.25 (1.15-1.35)	1.16 (1.07-1.25)

HR adjusted for: maternal age at delivery, parity, neighbourhood income quintile, rural residence, immigration status, stable and unstable chronic conditions, history of assault, and history of mental illness (in unstratified models).

Abbreviations: HR: hazard ratio, aHR: adjusted hazard ratio, CI: confidence interval

Supplementary Table 9: Unadjusted and adjusted associations between a history of concussion and severe maternal mental illness, including pregnancy and child characteristics in multivariable analyses.

Stratum	History of concussion	Number with outcome	Incidence per 1,000 person years (95% CI)	HR (95% CI)	aHR (95% CI)
Total cohort	No (N = 736,689)	49,928	7.9 (7.9-8.0)	1.00 (Referent)	1.00 (Referent)
	Yes (N = 18,064)	2,033	14.7 (14.0-15.3)	1.82 (1.74-1.90)	1.25 (1.19-1.31)
No history of mental illness	No (N = 511,550)	19,645	4.9 (4.9-5.0)	1.00 (Referent)	1.00 (Referent)
	Yes (N = 10,712)	688	8.2 (7.6-8.8)	1.65 (1.53-1.78)	1.33 (1.23-1.43)
History of outpatient care for mental illness	No (N = 188,307)	16,450	9.9 (9.8-10.1)	1.00 (Referent)	1.00 (Referent)
	Yes (N = 5,411)	642	15.0 (13.9-16.2)	1.48 (1.37-1.60)	1.29 (1.19-1.40)
History of acute care for mental illness	No (N = 36,832)	11,746	46.3 (45.5-47.1)	1.00 (Referent)	1.00 (Referent)
	Yes (N = 1,941)	703	59.4 (55.1-63.9)	1.24(1.15-1.33)	1.14 (1.05-1.23)

HR adjusted for: maternal age at delivery, parity, neighbourhood income quintile, rural residence, immigration status, stable and unstable chronic conditions, history of assault, history of mental illness (in unstratified models), serious pregnancy-induced hypertension, gestational diabetes, instrumental delivery, caesarean section, preterm birth <37 weeks gestation, small for gestational age, neonatal intensive care unit admission, and child mortality.

Abbreviations: HR: hazard ratio, aHR: adjusted hazard ratio, CI: confidence interval