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Supplementary appendix

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SUPPLEMENTARY INFORMATION

Obstetric and neonatal outcomes in pregnant women with and without a history of specialist mental healthcare: a national population-based cohort study using linked routinely collected data in England.

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DEFINITION OF A MATERNITY EPISODE IN HES

A maternity episode was defined as any record that contained valid information about mode of birth in either the procedure fields (OPCS-4 codes: R17.1 to R25.9) or in the HES maternity tail. Births before 24 completed weeks of gestation and multiple births (ICD-10 codes: Z37.2–Z37.7 or strong evidence of a multiple birth in the HES maternity tail (e.g., presence two or more distinct recorded birthweights) were excluded. If a woman gave birth more than once in the 4-year study period, one of the eligible births was chosen at random to be included in the study. Information on additional (previous or subsequent) births were not included in the analysis and women only appeared once in the maternity cohort.

DEFINITION OF THE MATERNAL CHARACTERISTICS USED FOR RISK ADJUSTMENT

Maternal age was grouped into four categories (under 25, 25-34, 35-39, above 40 years). Parity and previous caesarean section was derived from the HES maternity tail and if not available there determined by ‘looking back’ at HES records of previous hospital care episodes.* Maternal ethnicity was collapsed into 5 groups: White, South Asian, Black, Mixed, and Other.** Information about pre-existing diabetes mellitus and pre-existing hypertension, gestational diabetes and pre-eclampsia/eclampsia was derived from the diagnosis codes in the HES maternity record, with women assumed not to have the condition if the code was not present. Socioeconomic deprivation was derived from the ranking of the Index of Multiple Deprivation 2019 (IMD) of 32,844 ‘lower super output areas’, small regions with typically 1500 inhabitants and 600 households, and grouped according to the quintiles of the national distribution.***

* Cromwell DA, Knight HE, Gurol-Urganci I. Parity derived for pregnant women using historical administrative hospital data: accuracy varied among patient groups. *J Clin Epidemiol.* May 2014;67(5):578-85. doi:10.1016/j.jclinepi.2013.10.011

** Department for Communities and Local Government. The English Indices of Deprivation 2015 Statistical Release 2015 [Available from: <https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015>

*** Government DfCaL. The English Indices of Deprivation 2015 Statistical Release. <https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015>

Supplementary Table 1: Outcomes and risk factor specification

Outcomes and risk factors	Numerator/coding	Denominator/coding
Perinatal death	Stillbirth: Defined using ICD-10 code (Z37·1) or birth status field (birstat_1=2,3,4) in maternity tail for providers with over 95% data completeness. In the United Kingdom stillbirth is defined as birth without signs of life occurring at or after 24+0 completed gestational weeks, based on estimated due date calculated using universally offered ultrasound scan at 11–13 weeks' gestation. 7-day neonatal mortality: Derived from Office for National Statistics (ONS) Mortality Data linked to HES and PDS birth notifications records for the baby	All singleton births.
Preterm birth	Defined using gestational age fields in HES maternity tail or birth notifications dataset: (gestat 1<37)	All singleton births
Small for gestational age	Defined as less than the tenth birthweight centile using the UK-WHO charts ¹⁶ . Birthweight centiles are calculated using birthweight, gestational age, sex of baby fields in HES maternity tail or birth notifications dataset.	All singleton births
English neonatal adverse outcome indicator (ENAOI)	ENAOI is defined as births with any of the following diagnoses/procedures: birthweight<1500 g, gestational age under 32 completed weeks, 28-day neonatal mortality, respiratory distress syndrome, seizure, intraventricular haemorrhage (grade 3/4), cerebral infarction, periventricular leukomalacia, birth trauma, hypoxic ischemic encephalopathy, necrotizing enterocolitis, sepsis / septicaemia, pneumonia, respiratory disease, bacterial meningitis, resuscitation, mechanical ventilation / CPAP / high flow nasal oxygen, central venous or arterial catheter, pneumothorax requiring intercostal catheter, any intravenous fluids, any body cavity surgical procedure, therapeutic hypothermia. Coding of these diagnoses and procedures can be found in Knight HE, Oddie SJ, Harron KL, Aughey HK, van der Meulen JH, Gurol-Urganci I, et al. Establishing a composite neonatal adverse outcome indicator using English hospital administrative data. Arch Dis Child Fetal Neonatal Ed. 2019;104(5):F502-9.	All liveborn singleton births
Maternal morbidity outcome indicator (EMMOI), excluding acute psychosis	EMMOI is defined as births with any of the following morbid events/diagnoses/procedures: acute abdomen, acute renal failure, cardiac arrest/ failure or infarction, cerebral oedema or coma, disseminated intravascular coagulopathy, cerebrovascular accident, major complications of anesthesia, obstetric embolism (including amniotic fluid embolism), shock, sickle cell anemia with crisis, status asthmaticus, status epilepticus, uterine rupture, eclampsia, sepsis, cerebral venous thrombosis, assisted ventilation including tracheostomy, curettage in combination with a general anesthetic, dialysis, evacuation of hematoma, hysterectomy, procedures to reduce blood flow to uterus, re-closure of disrupted caesarean section wound, repair of bladder or cystostomy and repair of intestine. Coding of these diagnoses and procedures can be found in Nair M, Kurinczuk JJ, Knight M. Establishing a National Maternal Morbidity Outcome Indicator in England: A Population-Based Study Using Routine Hospital Data. PloS one. 2016;11(4):e0153370Nair et al 2016.	All singleton births
Pre-eclampsia/eclampsia	ICD-10 codes: O14 and O15	All singleton births
Gestational diabetes	ICD-10 codes: O24.4	All singleton births
Pre-existing diabetes mellitus	ICD-10 codes: E10, E11, E13, E14, O24.0, O24.1, O24.2, O24.3	All singleton births
Pre-existing hypertension	ICD-10 codes: I10-I15, O10, O11	All singleton births

ICD-10, International Classification of Diseases, tenth revision; *OPCS*, Censuses and Surveys Classification of Surgical Operations and Procedures; *UK-WHO*, United Kingdom–World Health Organization.

Supplementary Table 2. Distribution of neonatal adverse outcomes according to pre-pregnancy specialist mental healthcare.

	All births	Women with no pre-pregnancy specialist mental healthcare.	Women with pre-pregnancy specialist mental healthcare.
Frequency of stillbirth and neonatal death <7 days n(%); missing 59,754 (2.9%)	n=2,021,289	n=1,873,823	n=147,466
Stillbirth	6,833 (0.36%)	6,833 (0.36%)	567 (0.38%)
Neonatal death <7 days	1,721 (0.09%)	1,563 (0.08%)	158 (0.11%)
Frequency of adverse perinatal outcomes in the composite ENAOI measure, liveborn births, n (%); missing 29,939 (1.5%)	n=1,983,950	n=1,839,124	n=144,826
Neonatal death <28 days	2,423 (0.12%)	2,181 (0.12%)	242 (0.17%)
Birthweight < 1500g	1,1759 (0.59%)	10,448 (0.57%)	1,311 (0.91%)
Gestational age < 32 weeks	29,448 (1.48%)	27,258 (1.48%)	2,190 (1.51%)
Respiratory distress syndrome	39,293 (1.98%)	34,780 (1.89%)	4,513 (3.12%)
Seizure	3,253 (0.16%)	2,931 (0.16%)	322 (0.22%)
Intraventricular haemorrhage (grades 3 or 4)	801 (0.04%)	718 (0.04%)	83 (0.06%)
Cerebral infarction	198 (0.01%)	184 (0.01%)	14 (0.01%)
Periventricular leukomalacia	346 (0.02%)	294 (0.02%)	52 (0.04%)
Birth trauma	1,759 (0.09%)	1,638 (0.09%)	121 (0.08%)
Hypoxic ischaemic encephalopathy	4,440 (0.22%)	4,051 (0.22%)	389 (0.27%)
Necrotising enterocolitis	1,855 (0.09%)	1,660 (0.09%)	195 (0.13%)
Sepsis/septicaemia	7,336 (0.37%)	6,621 (0.36%)	715 (0.49%)
Pneumonia	5,608 (0.28%)	5,138 (0.28%)	470 (0.32%)
Other respiratory outcomes	4,920 (0.25%)	4,441 (0.24%)	479 (0.33%)
Chronic respiratory disease originating in perinatal period	4,079 (0.21%)	3,621 (0.20%)	458 (0.32%)
Bacterial meningitis	1,139 (0.06%)	1051 (0.06%)	88 (0.06%)
Resuscitation	10,392 (0.52%)	9,311 (0.51%)	1081 (0.75%)
Ventilatory support (mechanical or CPAP)	77,512 (3.91%)	69,291 (3.77%)	8,221 (5.68%)
Central venous or arterial catheter	21,118 (1.06%)	18,895 (1.03%)	2,223 (1.53%)
Pneumothorax requiring intercostal catheter	5,486 (0.28%)	5,020 (0.27%)	466 (0.32%)
Any IV fluids	7,696 (0.39%)	7,123 (0.39%)	573 (0.40%)
Transfusion of blood or blood products	521 (0.03%)	477 (0.03%)	44 (0.03%)
Any body cavity surgical procedure	8,046 (0.41%)	7,262 (0.39%)	784 (0.54%)
Therapeutic hypothermia	2,644 (0.13%)	2,412 (0.13%)	232 (0.16%)

* CPAP, Continuous positive airway pressure

Supplementary Table 3. Distribution of maternal morbidity according to pre-pregnancy specialist mental healthcare.

	All births	Women with no pre-pregnancy specialist mental healthcare.	Women with pre-pregnancy specialist mental healthcare.
Composite outcome (91,523 missing, 4.4%)	n=1989520	n=1844575	n=144945
	17,968 (0.90%)	16,528 (0.90%)	1,440 (0.99%)
Morbid events/ diagnosis			
Acute abdomen	98 (0.005%)	92 (0.005%)	6 (0.004%)
Acute renal failure	2,150 (0.11%)	1,990 (0.11%)	160 (0.11%)
Cardiac arrest/ failure or infarction	1,045 (0.05%)	936 (0.05%)	109 (0.08%)
Cerebral oedema or coma	#	62 (0.003%)	#
Disseminated intravascular coagulopathy	#	19 (0.001%)	#
Cerebrovascular accident	72 (0.004%)	66 (0.004%)	6 (0.004%)
Major complications of anaesthesia	174 (0.01%)	159 (0.01%)	15 (0.01%)
Obstetric embolism (including amniotic fluid embolism)	965 (0.05%)	851 (0.05%)	114 (0.08%)
Shock	636 (0.03%)	588 (0.03%)	48 (0.03%)
Sickle cell anaemia with crisis	109 (0.01%)	98 (0.01%)	11 (0.01%)
Status asthmaticus	70 (0.004%)	53 (0.003%)	17 (0.012%)
Status epilepticus	35 (0.002%)	23 (0.001%)	12 (0.008%)
Uterine rupture	1,357 (0.07%)	1,249 (0.07%)	108 (0.07%)
Eclampsia	1,112 (0.06%)	1,019 (0.06%)	93 (0.06%)
Sepsis	7,099 (0.36%)	6,572 (0.36%)	527 (0.36%)
Cerebral venous thrombosis	#	6 (0.0003%)	#
Procedures indicating morbidity			
Assisted ventilation including tracheostomy	576 (0.03%)	522 (0.03%)	54 (0.04%)
Curettage in combination with a general anaesthetic	#	19 (0.001%)	#
Dialysis	#	61 (0.003%)	#
Evacuation of haematoma	1,344 (0.07%)	1,263 (0.07%)	81 (0.06%)
Hysterectomy	317 (0.02%)	289 (0.02%)	28 (0.02%)
Procedures to reduce blood flow to uterus	250 (0.01%)	232 (0.01%)	18 (0.01%)
Re-closure of disrupted caesarean section wound	623 (0.03%)	578 (0.03%)	45 (0.03%)
Repair of bladder or cystostomy	991 (0.05%)	914 (0.05%)	77 (0.05%)
Repair of intestine	#	142 (0.01%)	#

Suppressed because number is less than or equal to five; total also suppressed, when one column is less than or equal to five.

Supplementary Table 4. Full logistic regression results according to Model 4 (see Table 2 in the paper) for all five outcomes.

	Stillbirth and neonatal mortality		Preterm birth		Small for gestational age		Neonatal adverse outcome		Maternal morbidity	
	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
No contact	Reference		Reference		Reference		Reference		Reference	
Community care contact; > 5 years	1.12 (0.93,1.35)	0.229	1.31 (1.12,1.52)	0.001	1.20 (1.13,1.27)	<0.001	1.19 (1.02,1.38)	0.024	1.07 (0.94,1.23)	0.312
TYPE (ref: community, >5yrs)										
Crisis resolution team	1.10 (0.93,1.30)	0.282	1.16 (1.09,1.24)	<0.001	1.05 (1.00,1.10)	0.074	1.15 (1.06,1.24)	<0.001	0.90 (0.79,1.03)	0.117
Hospital admission	1.32 (1.00,1.75)	0.054	1.38 (1.22,1.55)	<0.001	1.22 (1.12,1.33)	<0.001	1.46 (1.29,1.66)	<0.001	1.01 (0.79,1.28)	0.963
TIMING (ref: community, >5yrs)										
1-5 years	0.91 (0.76,1.09)	0.300	1.07 (1.01,1.13)	0.018	1.07 (1.01,1.14)	0.029	1.06 (1.00,1.12)	0.034	1.11 (0.96,1.29)	0.164
< 1 year	1.02 (0.83,1.25)	0.886	1.26 (1.18,1.33)	<0.001	1.17 (1.09,1.26)	<0.001	1.20 (1.13,1.28)	<0.001	1.21 (1.03,1.41)	0.017
Maternal age										
18 to 24	1.02 (0.82,1.26)	0.884	1.09 (1.07,1.11)	<0.001	1.22 (1.20,1.25)	<0.001	1.03 (1.00,1.05)	0.028	0.97 (0.93,1.02)	0.238
25 to 34	Reference		Reference		Reference		Reference		Reference	
35 to 39	1.09 (1.01,1.19)	0.037	1.05 (1.00,1.10)	0.039	1.03 (1.01,1.06)	0.011	1.05 (1.01,1.10)	0.013	1.10 (1.06,1.16)	<0.001
40 and over	0.92 (0.84,1.02)	0.133	1.21 (1.12,1.32)	<0.001	1.06 (1.02,1.10)	0.004	1.16 (1.08,1.24)	<0.001	1.28 (1.19,1.38)	<0.001
Parity										
Nulliparous	Reference		Reference		Reference		Reference		Reference	
Multiparous, no previous cs	0.81 (0.75,0.88)	<0.001	0.99 (0.88,1.11)	0.87	0.64 (0.61,0.66)	<0.001	0.81 (0.69,0.96)	0.01	0.60 (0.53,0.67)	<0.001
Multiparous, with previous cs	1.02 (0.93,1.11)	0.710	1.31 (1.23,1.38)	<0.001	0.54 (0.53,0.56)	<0.001	1.07 (0.97,1.17)	0.2	1.37 (1.28,1.46)	<0.001
Ethnicity										
White	Reference		Reference		Reference		Reference		Reference	
South Asian	1.27 (0.92,1.75)	0.144	1.24 (0.92,1.67)	0.159	2.44 (2.31,2.58)	<0.001	1.32 (0.99,1.76)	0.059	1.49 (1.39,1.60)	<0.001
Black	1.22 (0.82,1.82)	0.323	1.04 (0.91,1.18)	0.575	1.61 (1.55,1.69)	<0.001	1.39 (1.28,1.50)	<0.001	1.80 (1.67,1.95)	<0.001

Mixed	1.26 (1.09,1.47)	0.003	1.01 (0.96,1.06)	0.741	1.44 (1.38,1.51)	<0.001	1.08 (1.03,1.13)	0.002	1.23 (1.08,1.40)	0.002
Other stated	0.85 (0.74,0.99)	0.037	0.85 (0.82,0.89)	<0.001	1.30 (1.23,1.37)	<0.001	0.95 (0.90,1.00)	0.055	1.49 (1.33,1.66)	<0.001
Socioeconomic deprivation										
Least deprived = quintile 1	Reference		Reference		Reference		Reference		Reference	
quintile 2	0.94 (0.83,1.06)	0.319	1.04 (0.99,1.09)	0.084	1.08 (1.06,1.11)	<0.001	1.03 (0.98,1.09)	0.226	1.08 (1.01,1.16)	0.026
quintile 3	0.87 (0.65,1.17)	0.361	1.12 (1.08,1.17)	<0.001	1.17 (1.14,1.21)	<0.001	1.10 (1.05,1.16)	<0.001	1.14 (1.05,1.23)	0.002
quintile 4	0.93 (0.64,1.34)	0.685	1.22 (1.16,1.27)	<0.001	1.31 (1.26,1.36)	<0.001	1.17 (1.10,1.25)	<0.001	1.22 (1.11,1.33)	<0.001
Most deprived = quintile 5	1.17 (0.91,1.50)	0.217	1.33 (1.18,1.48)	<0.001	1.46 (1.40,1.52)	<0.001	1.14 (1.02,1.28)	0.023	1.24 (1.12,1.37)	<0.001
Pregnancy risk factors										
Pre-existing diabetes	1.63 (1.09,2.45)	0.018	4.45 (3.31,5.99)	<0.001	0.49 (0.43,0.56)	<0.001	3.00 (2.36,3.82)	<0.001	1.55 (1.36,1.78)	<0.001
Pre-existing hypertensive conditions	1.50 (1.07,2.11)	0.017	2.42 (2.14,2.73)	<0.001	1.66 (1.55,1.78)	<0.001	1.94 (1.75,2.16)	<0.001	2.60 (2.28,2.96)	<0.001
Gestational diabetes	0.73 (0.62,0.85)	<0.001	1.33 (1.18,1.51)	<0.001	0.62 (0.58,0.65)	<0.001	1.11 (1.02,1.21)	0.02	1.12 (1.05,1.19)	<0.001
Pre/eclampsia	1.73 (1.36,2.19)	<0.001	5.69 (4.74,6.83)	<0.001	2.93 (2.81,3.05)	<0.001	3.45 (2.94,4.04)	<0.001	7.33 (6.48,8.30)	<0.001