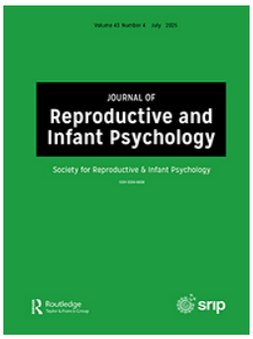

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Associations between postpartum haemorrhage, postnatal mental health and longer term mental illness: a record-linked cohort study

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ABSTRACT

Aim: To investigate the associations between primary postpartum haemorrhage (PPH), postnatal mental health and longer-term mental illness in a high-income setting.

Methods: A population-based retrospective cohort study of 18,798 women giving birth between 2008 and 2016 in Grampian, Scotland, was conducted, using linked data from the Aberdeen Maternity and Neonatal Databank and Scottish administrative healthcare datasets. 'Longer-term mental illness' was assessed using a composite outcome comprising mental-health related hospitalisation, prescription or death, from the end of the first postnatal year to 10 years after birth. We used extended Cox regression models to investigate the association between primary PPH in any first or subsequent births (the exposure) and subsequent mental illness, adjusted for sociodemographic, past medical history and pregnancy and birth-related factors, stratified by the presence of mental illness in the first postnatal year.

Results: We found no association between PPH and longer-term mental illness beyond the first postnatal year, regardless of severity of PPH or mode of birth [adjusted hazard ratio (aHR) 0.97, 95% confidence interval (CI) 0.81–1.16, $p = 0.75$]. Women who received psychotropic medication, or were hospitalised for mental illness in the first postnatal year, were around 12 times more likely [aHR 12.77,95% CI 10.94–14.91,$p < 0.001$] to experience mental illness in the second and third postnatal year, with a continuing association for up to 10 years after the first postnatal year, independent of PPH status.

Conclusions: This study provides no evidence of an association between PPH and longer-term mental illness, after taking into account the presence of mental illness in the first postnatal year.

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Introduction

Postpartum haemorrhage (PPH) is a serious childbirth complication, with increasing incidence in high-income countries (Knight et al., 2010). In England, around 26% of births were complicated by PPH in 2024 (NHS England, 2024). Anxiety, postpartum depression and posttraumatic stress disorder (PTSD) are more prevalent among women who have had a PPH than in the general perinatal population, particularly where invasive interventions such as peripartum hysterectomy are required (van Steijn et al., 2020). Such births are also reported to be traumatic by women in qualitative studies (de la Cruz et al., 2013; Elmir et al., 2012). Therefore, it is possible that women who experience a PPH may be at increased risk of developing mental health problems in later life, mediated through birth trauma and the need for a longer recovery.

In our recent systematic review, we found limited evidence for an association between PPH and longer-term mental illness (Latt et al., 2023). Most quantitative studies have focused on the prevalence of mental illness in the first postnatal year after PPH and very few have examined associations between PPH and longer-term mental illness using appropriate comparison groups (Bernasconi et al., 2021; de la Cruz et al., 2016; Liu et al., 2021; Parry-Smith et al., 2021; van Steijn et al., 2020). Three recent studies have reported inconsistent results (Bernasconi et al., 2021; Liu et al., 2021; Parry-Smith et al., 2021). For example, an English study (Parry-Smith et al., 2021) did not find an association between PPH and mental illness beyond 1 year after birth, while a Swiss study (Bernasconi et al., 2021) showed that severe PPH can increase the risk of PTSD by five times (aOR = 5.1, $p = 0.001$) up to 8 years after birth.

An additional consideration is that women who experience perinatal depression and anxiety are more susceptible to longer-term psychiatric disorders (Meltzer-Brody & Stuebe, 2014). Less is known about the trajectories of birth-related PTSD, but one study found that 13% of women who had birth-related PTSD at 4–6 weeks postpartum progressed to chronic PTSD at 12 months postpartum (Yildiz et al., 2018). It is possible that the potential acute stressor of a birth complicated by a PPH could have a different impact on the risk of developing a longer-term mental illness in women already affected by perinatal mental illness, compared with women unaffected by perinatal mental illness (Erickson et al., 2022). It is important, therefore, to consider this potential effect modification when investigating associations between PPH and longer-term mental illness.

This study aimed to investigate the association between primary PPH and longer-term mental illness, beyond the first postnatal year, while assessing how the presence of mental illness in the first postnatal year modifies this association.

Materials and methods

We used a population-based retrospective record-linked cohort study and reported the findings according to the REporting of studies Conducted using Observational Routinely collected Data (RECORD) guideline (S1 File) (Benchimol et al., 2015).

Data sources and linkage

Data about PPH, and maternal and neonatal characteristics from the Aberdeen Maternity and Neonatal Databank (AMND), which includes socio-demographic, pregnancy, birth

and neonatal data for all pregnancy events occurring in the Grampian Region of Scotland from 1949 to the present day (Ayorinde et al., 2016), were linked to the following Scottish healthcare datasets: Scottish Morbidity Record (SMR) 01 and 04; Prescribing Information System (PIS); National Records of Scotland (NRS); and Trakcare, NHS Scotland's patient management system (Table S1, S2 File). Data linkage was processed at the Grampian Data Safe Haven (DaSH) in Scotland by DaSH staff using deterministic record linkage (Gill et al., 1993). DaSH staff pseudo-anonymised the linked dataset, before releasing it to the authors (SL, RR, CO) who then accessed the linked data through the DaSH via secure VPN.

Identification of cohort

We included all birth records of women in the AMND who gave birth after 24 completed weeks' gestation in Aberdeen Maternity Hospital, from 1 January 2008 to 31 December 2016 and were permanent registered patients with NHS Scotland (Ayorinde et al., 2016). Both singletons and multiple births were included.

We excluded women whose first birth was not recorded in AMND, those with conflicting parity information – for example, where recorded parity was the same for two birth records of the same woman – and those who had at least of one of their births outside the Grampian region. Birth records of women for whom the inter-pregnancy interval was less than a year, or where the date of transfer out of the Grampian region was less than a year from the most recent birth were also excluded to form four exposure groups based on 'postnatal mental illness' within 1 year after birth as described below.

Women with a previous history of mental illness were not excluded from the cohort due to the relapsing and recurrent nature of mental illness (Jones et al., 2014; Viguera et al., 2007).

Exposure

Primary PPH definition

We defined primary PPH as blood loss of 500 ml or more within 24 h birth. We chose this definition to be inclusive, to account for potential underestimation of blood loss, and because the physiological impact of blood loss is likely to be the same, irrespective of mode of birth (Borovac-Pinheiro et al., 2018; Knight et al., 2010). To minimise potential misclassification of exposure to PPH, for births in which the blood loss volume was recorded as less than 500 ml, but a PPH management technique (Bakri ballooning, arterial embolisation and emergency peripartum hysterectomy) was also recorded, a PPH was considered to have occurred.

To investigate the association between PPH and women's longer-term mental illness independent of postnatal illness within the first postnatal year, we described four exposure groups. These were based on (i) whether the woman had a PPH in any of the birth records in AMND and (ii) whether they had 'postnatal mental illness' – defined as having a record of (a) prescription of psychotropic medication and/or (b) a mental health-related hospitalisation, within 1 year of any of their births (MH1).

The four exposure groups were:

(1) ***No PPH and No MH1*:** unexposed' reference group: Women who did not have a PPH and did not have 'postnatal mental illness' as defined above
(2) ***No PPH and MH1***: Women who did not have a PPH but had postnatal mental illness
(3) ***Any PPH and No MH1***: Women who had at least one PPH, but had no postnatal mental illness
(4) ***Any PPH and MH1***: Women who had at least one PPH, and had postnatal mental illness

Outcomes

The primary outcome for this study was 'longer-term mental illness', measured at up to 10 years after the first postnatal year. A composite outcome (Table S2, S2 File) was used to capture a wide range of common mental illnesses, defined as the time to first occurrence of one of the following after the first birth (excluding any occurrence in the first postnatal year after any birth):

- At least three prescriptions within any 365-day period of commonly prescribed psychotropic medications (Public Health Scotland, 2021)
- Any mental health-related hospitalisation with selected ICD-10 diagnostic codes recorded as the main condition of diagnosis or in any other diagnostic fields
- Death in which the main or secondary cause was suicide, or intentional self-inflicted injury or poisoning.

Follow-up

The follow-up for all women began from 1 year following the date of their first birth recorded in the AMND between 2008 and 2016. The first postnatal year following any birth, including the first birth, did not contribute towards the total follow-up duration since exposure groups were formed based on whether the woman had postnatal mental illness within the first year of birth. The follow-up period ended on either the completion of data linkage (i.e. 31 December 2018 up to 10 years after birth), or the date of the outcome event, or the date of loss to follow up (i.e. date of migration outside the Grampian region, as recorded in Trakcare), or the date of death as recorded in NRS deaths, whichever came earlier (Figure S1, S2 File).

Statistical analysis

We summarised the maternal socio-demographic and clinical characteristics, and outcome events for each exposure group. Univariable survival analysis was performed using Cox proportional hazards (PH) models. Unadjusted incidence rates and hazard ratios (HRs) were reported separately for each exposure group, compared with women who did not have a PPH and had no postnatal mental illness. Potential confounders were included in the multivariable models if they were associated with PPH, increased the risk of MH event in the unexposed group, and if they were not plausibly on the causal pathway between PPH and outcome (Webb et al., 2019). Multivariable Cox PH regression models were used to assess the association between PPH and mental health outcome-free survival,

calculating adjusted hazard ratios (aHRs) with 95% CIs. These were fitted by sequentially adjusting for each category of potential confounder starting with the baseline model adjusted for year of birth, followed by further adjustment for maternal age, ethnicity, Body Mass Index at antenatal booking (BMI) and Scottish Index of Multiple Deprivation (Model 1). A second model (Model 2) built on Model 1 by further adjustment for past medical history (anaemia and bleeding disorders, diabetes, cardiovascular disease, congenital heart disease, psychiatric and mental disorders) and smoking status. Finally, the fully adjusted model (Model 3) further adjusted for mode of birth, obstetric complications (gestational diabetes, hypertensive disorders of pregnancy (HDP), prelabour rupture of membranes (PROM) or preterm prelabour rupture of membranes (PPROM) and baby's characteristics (gestation at birth and birthweight). All variables included are summarised in Supplementary Table S3 (S2 File).

Informed by Log–log plots (Figure S2, S2 File) and the global PH test, we used extended multivariable Cox regression models to estimate time-varying HRs for three follow-up periods after birth for each exposure group. We conducted two sensitivity analyses using the final model (model 3) for the association between PPH and longer-term mental illness, (a) after excluding births to women with a pre-existing history of psychiatric and mental health disorders, and (b) after restricting the outcome to mental health-related hospitalisation.

The proportion of missing data was lower than 5%. Since this was a cohort study using a routine administrative data, missing values were unlikely to be influenced by mental health outcome events. We therefore conducted a complete case analysis (Little & Rubin, 2020). Data were analysed using Stata software version 16 (StataCorp, 2019).

Results

After applying all exclusion criteria, the dataset comprised 26,155 birth records from 18,798 women. Within this cohort, 8,578 women (46%) had no PPH and no indication of postnatal mental illness (reference group), 1,053 women (6%) had no PPH and no postnatal mental illness (No PPH and No MH1), 8,140 women (43%) had at least one primary PPH, but no postnatal mental illness (Any PPH and No MH1) and 1,027 women (6%) had at least one primary PPH and postnatal mental illness after at least one of their births (Any PPH and MH1). Overall, 2080 women (11%) had a mental health-related prescription or hospitalisation in the first year after at least one of their births (Figure S3, S2 File, Table 1). The sociodemographic and clinical characteristics of each exposure group are reported in Table 1.

Figure 1 shows the number of each type (prescription or hospitalisation) of 'first occurrence' mental health event (i.e. primary outcome), followed by the number of 'second occurrence' mental health events, i.e. a mental health-related hospitalisation after a psychotropic medication or vice versa. Irrespective of PPH exposure, almost 70% of women with a postnatal mental illness had longer-term mental illness, compared with around 10% without a postnatal mental illness (Figure 1).

For all groups, prescription records accounted for almost all (≥98%) first mental health events contributing to the composite outcome, with hospitalisation accounting for the remaining 2% (Figure 1). No deaths from suicide or self-inflicted injury were observed. Mental health event-free survival probabilities (Figure S4, S2 File) were similar for women who had at least one PPH and women who did not have a PPH, given the same postnatal mental illness 'status'.

Table 1. Sociodemographic and clinical characteristics of the women included in the study.

	No PPH and No MH1[a] (Reference group)		No PPH and MH1[b]		Any PPH and No MH1[c]		Any PPH and MH1[d]		All women	
	n = 8,578		n = 1,053		n = 8,140		n = 1,027		n = 18,798	
Characteristics	n	%	n	%	n	%	n	%	n	%
Year of first childbirth										
2008–2012	4,879	56.9	718	68.2	4,634	56.9	706	68.7	10,937	58.2
2013–2016	3,699	43.1	335	31.8	3,506	43.1	321	31.3	7,861	41.8
Age at first childbirth (mean. SD)	28	5.5	25	6.1	29	5.3	28	6.0	28	5.6
<25	2,394	27.9	543	51.6	1,412	17.4	345	33.6	4,694	25.0
25–29	2,802	32.7	245	23.3	2,603	32.0	276	26.9	5,926	31.5
30–34	2,437	28.4	178	16.9	2,751	33.8	263	25.6	5,629	29.9
≥35	945	11.0	87	8.3	1,374	16.9	143	13.9	2,549	13.6
Ethnicity										
White	7,671	89.4	1,016	96.5	7,017	86.2	982	95.6	16,686	88.8
Black, Asian and Others	872	10.2	33	3.1	1,090	13.4	44	4.3	2,039	10.9
Missing	35	0.4	4	0.4	33	0.4	1	0.1	73	0.4
No. of births										
1	5,732	66.8	546	51.9	4,789	58.8	408	39.7	11,475	61.0
2	2,553	29.8	427	40.6	3,024	37.1	535	52.1	6,539	34.8
≥3	293	3.4	80	7.6	327	4.0	84	8.2	784	4.2
Scottish Index of Multiple Deprivation quintile at first birth										
1 (Most deprived)	1,152	13.4	179	17.0	971	11.9	177	17.2	2,479	13.2
2	1,360	15.9	196	18.6	1,197	14.7	182	17.7	2,935	15.6
3	2,014	23.5	188	17.9	2,011	24.7	221	21.5	4,434	23.6
4	2,794	32.6	311	29.5	2,898	35.6	331	32.2	6,334	33.7
5 (Least deprived)	370	4.3	14	1.3	425	5.2	11	1.1	820	4.4
Missing	1,152	13.4	179	17.0	971	11.9	177	17.2	2,479	13.2
BMI at first antenatal visit (kg/m^2) at first birth										
<18.5	308	3.6	49	4.7	175	2.2	30	2.9	562	3.0
18.5–24	4,841	56.4	562	53.4	3,906	48.0	447	43.5	9,756	51.9
25–29	2,075	24.2	253	24.0	2,284	28.1	278	27.1	4,890	26.0
≥30	1,095	12.8	156	14.8	1,493	18.3	249	24.3	2,993	15.9
Missing	259	3.0	33	3.1	282	3.5	23	2.2	597	3.2
Past medical history before first birth										
Anaemia and coagulation disorders	78	0.9	12	1.1	111	1.4	11	1.1	212	1.1
Diabetes	31	0.4	<5	<0.5	71	0.9	10	1.0	112–116	<1
Psychiatric or mental health disorder	738	8.6	394	37.4	726	8.9	420	40.9	2,278	12.1
Cardiovascular disease	283	3.3	33	3.1	343	4.2	49	4.8	708	3.8
Congenital heart disease	27	0.3	7	0.7	39	0.5	11	1.1	84	0.5
Smoking status at first birth										
Non-smoker	6,691	78.0	607	57.6	6,839	84.0	737	71.8	14,874	79.1
Smoker	956	11.1	282	26.8	576	7.1	145	14.1	1,959	10.4
Ex-smoker	834	9.7	146	13.9	640	7.9	134	13.1	1,754	9.3
Missing	97	1.1	18	1.7	85	1.0	11	1.1	211	1.1
Mode of birth at first birth										
Spontaneous vaginal	5,482	63.9	678	64.4	1,795	22.1	250	24.3	8,205	43.7
Instrumental	2,152	25.1	270	25.6	2,522	31.0	314	30.6	5,258	28.0
Caesarean section	936	10.9	103	9.8	3,811	46.8	460	44.8	5,310	28.3
Missing	8	0.1	2	0.2	12	0.2	3	0.3	25	0.1
Number of PPH per woman										
Never had a PPH	8,578	100	1,053	100	NA		NA		9,631	51.2
1	NR		NR		6,905	85.0	890	87.0	7,795	41.5
2–3 times	NR		NR		1,235	15.0	137	13.0	1,372	7.3

[a]Women with no PPH and no postnatal mental illness.
[b]Women with no PPH, but with postnatal mental illness after at least one birth.
[c]Women with at least one PPH, but no postnatal mental illness.
[d]Women with at least one PPH and with postnatal mental illness after at least one birth.

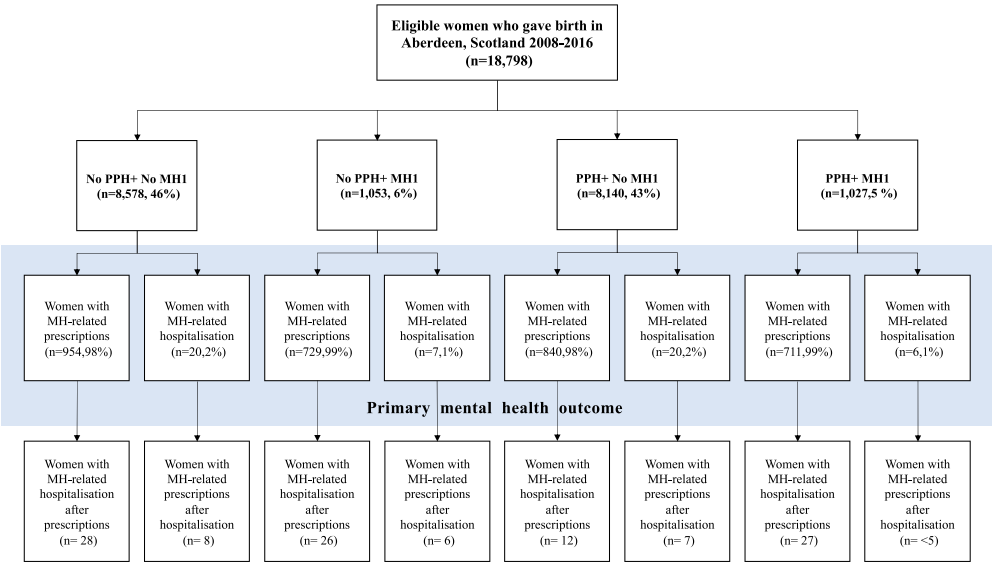

Figure 1. Events contributing to the composite mental health outcome, and subsequent mental health events in each exposure group. A flow chart showing the breakdown of mental health outcomes among the cohort (18,798 eligible women who gave birth in Aberdeen, Scotland 2008-16), shown in a box into the four exposure groups ('No PPH, No MH1' – 8578 women, 46%; 'No PPH and MH1' – 1053 women, 6%; 'PPH, No MH1' – 8140 women, 43%; 'PPH and MH1' – 1027 women, 5%) in four boxes each connected to the box above with a downward facing arrow. For each of the four-exposure group, the number proportion of women with MH-related prescriptions or hospitalisation is shown in two boxes below, each connected with downward facing arrows. These constitute the primary mental health outcome and this is highlighted by blue shading. For the 'No PPH, No MH1' group, 954 women or 98% had a mental health-related prescription and 20 women or 2% had an MH-related hospitalisation. For the 'No PPH and MH1' group, 729 women or 99% had an MH-related hospitalisation and 7 women or 1% had an MH-related hospitalisation. The same pattern follows for the other two groups, showing the distribution of MH outcomes. Below each of these eight outcome boxes, there is another set of boxes, connected with downward facing arrows, showing the number of women who had a subsequent mental health event: the number of women who had an MH-related hospitalisation after a prescription, and the number of women who had an MH-related prescription after hospitalisation with small numbers in each group.

Univariable and multivariable Cox PH models

Among women with the same postnatal mental illness 'status', we found no evidence of a difference in the risk of having a longer-term mental illness during the follow-up period for women who at least one PPH, compared with women who did not have a PPH (HR: 0.93, 95% CI 0.85–1.02, $p = 0.99$) (Table 2). However, women with postnatal mental illness, were over 10 times more likely to develop a longer-term mental illness compared with women without postnatal mental illness, regardless of their PPH status (HR = 10.22 in No PPH and MH1; HR = 10.19 in PPH and MH1). The overall pattern of associations in the univariable analysis remained the same but was attenuated after adjusting for confounders (Table 2).

Table 2. Association between PPH and longer-term mental illness, with sequential adjustment for potential confounders.

	Base Model[a]			Model 1[b]			Model 2[c]			Model 3[d]		
	n = 18,798			n = 17,588			n = 17,490			n = 17,471		
Exposed groups	aHR	95% CI	p-value	aHR	95% CI	p-value	aHR	95% CI	p-value	aHR	95% CI	p-value
No PPH and No MH1		Reference			Reference			Reference			Reference	
No PPH and MH1	10.22	9.28–11.26	<0.001	8.93	8.08–9.88	<0.001	6.95	6.26–7.72	<0.001	6.86	6.17–7.62	<0.001
Any PPH and No MH1	0.93	0.85–1.02	0.13	0.99	0.90–1.09	0.81	0.99	0.90–1.09	0.78	0.93	0.84–1.03	0.16
Any PPH and MH1	10.19	9.24–11.23	<0.001	9.17	8.29–10.13	<0.001	7.27	6.55–8.07	<0.001	6.82	6.11–7.61	<0.001

[a]Base model adjusted for year of birth only.
[b]Model 1 adjusted for year of birth and sociodemographic factors (age at delivery, BMI, Ethnicity, Scottish index of multiple deprivation).
[c]Model 2 adjusted for variables in model 1, and additionally adjusted for pre-existing medical history of women (anaemia and coagulation disorders, diabetes, existing psychiatric or mental disorder, cardiovascular disease) and smoking status.
[d]Model 3 adjusted for variables in model 2, and additionally adjusted for pregnancy-related factors: mode of birth, obstetric complications (HDP, pre-labour rupture of membrane, preterm pre-labour rupture of membrane, gestational diabetes), gestation age at birth, baby's birthweight.

Extended multivariable Cox regression models for different time periods

Plots of hazard function against analysis time (Figure S2, S2 File) and the global PH test showed that the association between PPH and the MH outcome and the association between several confounding variables (year of birth, maternal age at childbirth, mode of birth, PROM or PPROM) and the MH outcome, were not constant over time ($p < 0.001$). Extended Cox regression models were conducted, with stratification by the variables violating the PH assumption. In the fully adjusted model (model 3), we found no association between PPH and longer-term mental illness, with no evidence of variation over different periods (Table 3). Time-varying aHRs were observed for the association between postnatal mental illness and longer-term mental illness, irrespective of PPH status. Within the first 2 years following the first postnatal year, in the fully adjusted model (model 3), women with postnatal mental illness were approximately 12 times more likely to develop a longer-term mental illness than women without postnatal mental illness, irrespective of their PPH status (aHR = 12.77 in No PPH and MH1; aHR = 12.59 in PPH and MH1). The increased risk persisted to approximately four times up to their fifth postnatal year, and almost doubled from six to 10 years after birth, irrespective of PPH status.

Sensitivity analyses

After excluding births to women with a history of mental illness, the association between PPH and longer-term mental illness remained consistent with the main analysis (Table S4, S2 File). In the second sensitivity analysis, after restricting the outcome to hospitalisation only, similar findings were observed, with no evidence of an association between PPH and longer-term mental health-related hospitalisation (Table S5, S2 File).

Discussion

Summary and interpretation of main findings

We explored the association between PPH and longer-term mental illness, beyond the first postnatal year, by investigating four exposure groups, defined by primary PPH and postnatal mental illness. We did not find any association between PPH and longer-term mental illness, from one to 10 years after the first postnatal year, among women who had a PPH compared with women who did not have a PPH, if their postnatal mental health 'status' was the same.

However, women with postnatal mental illness, irrespective of their PPH exposure, had a significantly higher incidence of longer-term mental illness compared with those without. Women who psychotropic medication or mental health-related hospitalisation in the first postnatal year, were 12 times more likely to develop a longer-term mental illness in their second and third postnatal year. Beyond these first 2 years of follow-up, this association remained, but was attenuated over time.

Previous studies investigating the impact of PPH on mental illness, focused on the first postnatal year (Eckerdal et al., 2016; Liu et al., 2021; Ricbourg et al., 2015; van Steijn et al., 2020), with some investigating outcomes within 5 years (de la Cruz et al., 2016; Michelet et al., 2015). These studies reported conflicting findings, with differing directions of association between PPH and postnatal mental illness, some of which may be explained by

Table 3. Association between PPH and longer-term mental illness for different time intervals following the first postnatal year, stratified by the presence of postnatal mental illness and with sequential adjustment for potential confounders.

		Base Model[a]			Model 1[b]			Model 2[c]			Model 3[d]		
		n = 18,798			n = 17,588			n = 17,490			n = 17,471		
Follow up	Exposure groups	aHR	95% CI	p	aHR	95% CI	p	aHR	95% CI	p	aHR	95% CI	p
1–2 years	No PPH and No MH1		Reference			Reference			Reference			Reference	
	No PPH and MH1	17.88	15.51–20.62	<0.001	16.86	14.52–19.57	<0.001	13.07	11.22–15.22	<0.001	12.77	10.94–14.91	<0.001
	Any PPH and No MH1	0.93	0.79–1.10	0.40	0.97	0.82–1.15	0.72	0.98	0.83–1.16	0.83	0.97	0.81–1.16	0.75
	Any PPH and MH1	17.50	15.15–20.20	<0.001	16.34	14.09–18.96	<0.001	12.79	10.98–14.89	<0.001	12.59	10.70–14.82	<0.001
3–5 years	No PPH and No MH1		Reference			Reference			Reference			Reference	
	No PPH and MH1	6.37	5.46–7.44	<0.001	5.30	4.51–6.23	<0.001	4.14	3.51–4.88	<0.001	4.03	3.41–4.76	<0.001
	Any PPH and No MH1	0.96	0.85–1.08	0.49	1.04	0.92–1.17	0.55	1.03	0.91–1.17	0.63	0.96	0.84–1.10	0.55
	Any PPH and MH1	6.87	5.89–8.01	<0.001	5.88	5.01–6.89	<0.001	4.76	4.05–5.60	<0.001	4.50	3.80–5.34	<0.001
6–10 years	No PPH and No MH1		Reference			Reference			Reference			Reference	
	No PPH and MH1	3.19	1.75–5.81	<0.001	2.46	1.31–4.63	0.01	1.94	1.03–3.65	0.04	1.84	0.97–3.48	0.06
	Any PPH and No MH1	0.90	0.66–1.22	0.50	1.07	0.78–1.47	0.68	1.04	0.76–1.43	0.81	0.87	0.61–1.24	0.43
	Any PPH and MH1	2.49	1.21–5.14	0.01	2.38	1.15–4.92	0.02	2.08	1.01–4.30	0.05	1.76	0.84–3.70	0.14

[a]Base model adjusted for year of birth only.
[b]Model 1 adjusted for year of birth and sociodemographic factors (age at delivery, BMI, Ethnicity, Scottish index of multiple deprivation).
[c]Model 2 adjusted for variables in model 1, and additionally adjusted for pre-existing medical history of women (anaemia and coagulation disorders, diabetes, existing psychiatric or mental disorder, cardiovascular disease) and smoking status.
[d]Model 3 adjusted for variables in model 2, and additionally adjusted for pregnancy-related factors: mode of birth, obstetric complications (HDP, pre-labour rupture of membrane, preterm pre-labour rupture of membrane, gestational diabetes), gestation age at birth, baby's birthweight.
Follow up began after the first postnatal year.

differences in sample selection, follow-up time and different tools to measure mental illness. Many of these findings from earlier studies cannot be compared directly with our study's findings because of the different follow-up period in our study, which commenced after the first postnatal year. The purpose here was not to replicate earlier findings but to investigate longer-term outcomes.

To our knowledge, only three studies have investigated the association between PPH and longer-term mental illness beyond 5 years after birth (Bernasconi et al., 2021; Knight et al., 2016; Parry-Smith et al., 2021). Two English studies investigated longer-term mental illness up to 8 years after birth and reported no increase in the overall risk of anxiety, depression and severe mental illness following PPH beyond the first postnatal year (Knight et al., 2016; Parry-Smith et al., 2021). Our study's findings are consistent with these results. In contrast, a single-centre study of 142 women in Switzerland, reported an increased risk of depression and PTSD (aOR = 5.1, $p < 0.005$) among women who underwent arterial embolisation for PPH compared with matched controls with uneventful births, at an average of 8 years after birth (Bernasconi et al., 2021). While PPH itself was not directly associated with longer-term mental illness in our study, it is possible that traumatic birth events potentially associated with PPH, including, for example, negative experiences of care, or emergency management, and lack of support may mediate trajectories of longer-term mental health. Therefore, the extent to which any PTSD symptoms identified could be linked to PPH itself or to trauma associated with birth experiencesfor example, due to the interventions required or negative experiences of care, remains unclear. With the available data, we were unable to investigate PTSD as a separate outcome, and this kind of investigation was beyond the scope of our study, but is worthy of further exploration.

Our results show that having a mental illness in the first postnatal year, irrespective of the occurrence of PPH, increased the risk of having a longer-term mental illness in subsequent postnatal years. This is consistent with previous research demonstrating a strong association between perinatal depression or anxiety and long-term mood disorders (Meltzer-Brody & Stuebe, 2014). It is estimated that 14% of women who experience a psychiatric episode during the first month after birth will develop a bipolar disorder within the first 15 years after their initial postpartum episode (Munk-Olsen et al., 2012). Past history of psychiatric illness is one of the strongest predictors of postpartum depression, along with anxiety and depression during pregnancy, stressful life events and low levels of social support (Beck, 2001; Robertson et al., 2004). In a study from a London mental health provider, women who had severe mental illness in the 2 years before pregnancy had an increased risk of relapse during pregnancy and postpartum (Khapre et al., 2021). In our study, women who had postnatal mental illness were more likely to have had pre-existing mental health problems before their first birth, confirming the well-established link between pre-existing mental health problems, perinatal mental illness and its progression to longer-term mental illness.

Strengths and limitations

The strengths of this study include a large sample size and up to 10 years of follow-up for longer-term mental illness, minimising selection bias. Stratification by postnatal mental illness enabled investigation of the independent effects of PPH and postnatal mental

illness on longer-term mental illness. Using three data sources to identify outcome events increased the statistical power to identify an association between PPH and longer-term mental illness, if such an association exists. Including women with pre-existing mental health problems before their first birth in our cohort improved generalisability. We addressed potential confounding by adjusting for a wide range of potential confounders, including risk factors for PPH. However, there may be some residual confounding due to a lack of information about genetic risks, childhood abuse, addiction problems or abuse during pregnancy.

Our study has two main limitations. First, approximately 98% of the mental health outcome data were identified from prescriptions for psychotropic medications. Due to the complex nature of prescribing for mental illness, it was not possible to draw inferences about risks for specific mental illnesses from these data. Second, a large proportion of mild to moderate mental illness is managed using psychological interventions in community settings, without prescription of psychotropic medication or hospitalisation (National Institute of Health and Care Excellence [NICE], 2020). With the available linked data, it was not possible to identify women who had mental health symptoms or diagnoses, but were not prescribed medication or admitted to hospital. As a result, it is not possible to draw conclusions about any associations between PPH and relatively milder longer-term mental illness. It should also be noted that that women from Black and other minority ethnic groups have significantly lower access to perinatal mental health services compared with their White British counterparts (Jankovic et al., 2020). As a consequence, these women may be under-represented among the groups in our study identified as having postnatal or longer-term mental illness.

Conclusion

We did not find any evidence of association between PPH and longer-term mental illness, as indicated by the prescription of psychotropic medication or a mental health-related hospitalisation beyond the first postnatal year. This finding was unchanged after adjusting for confounders and irrespective of the presence of postnatal mental illness in the first postnatal year. Consistent with well-established evidence, our study showed a relationship between pre-existing mental illness, postnatal mental illness and longer-term mental illness.

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Disclosure statement

No potential conflict of interest was reported by the authors.

Contribution to authorship

SL, CO and RR had full access to all of the data in the study. SL and RR were responsible for the conceptualisation of the study with input from JK and FA. SL was responsible for statistical analysis and exporting the results from the Grampian Safe Haven with supervisory support from CO. All authors were involved in interpretation of the data. SL drafted the manuscript, and all authors were involved in interpretation of the data, and critical revision of the manuscript.

Data availability statement

The linked datasets generated and/or analysed during the current study cannot be made publicly available due to privacy and ethical restrictions. These data are stored in the Grampian Data Safe Haven, and the access to these data is strictly controlled and is subject to review by the University of Aberdeen's data steering committee, Caldicott Guardian (Grampian) and the NHS Grampian R&D, Scotland.

Details of ethics approval

This study was approved by the University of Aberdeen's AMND data steering committee, NHS Grampian R&D (Project number: 2021OG001E, IRAS reference: 290656) on 20 January 2021.

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