The final version of this paper was published in *BMC Pregnancy and Childbirth 2015;* 15:334

Title page: Trends and outcomes of postpartum haemorrhage, 2003-2011

Authors: Ford JB, Patterson JA, Seeho S, Roberts CL

Corresponding author:
Associate Professor Jane Ford
c/- University Department of Obstetrics and Gynaecology
Building 52, Royal North Shore Hospital, St Leonards NSW 2065
Australia
Email: jane.ford@sydney.edu.au
Phone: +61 2 9462 9793

The authors report no conflicts of interest.

Word count
Abstract: 271
Main text: 2191

Abstract

Background: While rates of postpartum haemorrhage (PPH) have continued to rise, it is not clear if the association with other morbidity and transfusion has changed over time. This study explores the recent trend in postpartum haemorrhage and risk factors for transfusion and other severe adverse maternal outcomes following postpartum haemorrhage, stratified by mode of delivery.

Methods: Linked birth and hospital data were used to examine ICD-10AM coded PPH and outcomes in maternal birth admission records, 2003-2011 in hospitals in New South Wales (NSW), Australia (N= 818,965 singleton pregnancies). Trends were calculated on the whole population, and among subgroups, and tested using the Cochran Armitage test for trend. Logistic regression models were developed separately for vaginal and caesarean births, and for a maternal morbidity composite indicator (excluding transfusion) and red cell transfusion. Adjusted odds ratios (aOR) for yearly change and 95% confidence intervals (CI) are presented. Adjustment included maternal (eg. age, country of birth) and pregnancy factors (eg. parity, interventions, pregnancy complications).

Results: Overall, there was a significant increase in the PPH rate, from 6.1% in 2003 to 8.3% in 2011 ($p<0.0001$). Having accounted for maternal and pregnancy factors, there was no significant increase in *morbidity* among women delivering vaginally with a PPH (aOR for yearly change 0.97 (0.94-1.00); $p=0.36$), and a slight decrease among women delivered by caesarean section (aOR 0.96 (0.92-0.99); $p<0.01$). There was a slight increase in *transfusions* for vaginal births (aOR 1.02 (1.00-1.03); $p<0.01$), however there was no significant trend amongst caesarean births (aOR 0.99 (0.97-1.01); $p=0.30$).

Conclusions: PPH has become more frequent, however this has not been associated with increased maternal morbidity. This suggests that the increase in PPH may represent fewer severe haemorrhages, well-managed haemorrhage or better recording of PPH.

Keywords: maternal morbidity; postpartum haemorrhage; transfusion;

Background

Postpartum haemorrhage rates have increased in the developed world[1]. At the same time, transfusion rates associated with childbirth have risen in Australia[2], Canada[3] and the United States[4]. It is unclear whether the increased rates of postpartum haemorrhage represent more severe haemorrhage. In Australia, the postpartum haemorrhage rate increased by around 25% from 1994 to 2002. During this period, the transfusion rate among women with postpartum haemorrhage increased by 500% (from 2% to 12%).[5]. Obstetric transfusions (not limited to women with postpartum haemorrhage) increased from 1.2% of births in 2001 to 1.6% of births in 2010[2].

Current population-based pregnancy and birth data do not include details of the amount of blood lost at postpartum haemorrhage, nor the quantity of blood transfused. In the absence of these details, post-haemorrhage outcomes such as maternal morbidity and transfusion may provide insight into whether bleeding is becoming more severe over time. Given increasing caesarean section rates and different risk factors reportedly associated with vaginal and caesarean births[6,7], it is worthwhile considering the outcomes following postpartum haemorrhage separately for these birth modes.

The aims of this study were to determine the recent trend in postpartum haemorrhage, rates of associated maternal morbidity and transfusion, and risk factors for adverse maternal outcomes following postpartum haemorrhage stratified by mode of delivery.

Methods

The study population consisted of all women with livebirths or stillborn infants of at least 20 weeks gestation in NSW hospitals between 2003 and 2011. Data on maternal demographics, the pregnancy, labour and birth were obtained from the Perinatal Data Collection (‘Birth data’). This is a legislated statewide record of all births in NSW, and is completed by the midwife or doctor at the time of birth. Data on maternal diagnoses and procedures were obtained from the Admitted Patients Data Collection (‘Hospital data’), which contains data collected on all private and public hospital discharges in NSW. Diagnoses and procedures associated with each hospital discharges are coded according to the 10th

revision of the International Classification of Diseases, Australian Modification (ICD10-AM)[8] and the Australian Classification of Health Interventions (ACHI)[9] respectively.

The Centre for Health Record Linkage performed probabilistic linkage of the hospital and birth data, to assign unique project identifiers to each mother, allowing both longitudinal linkage (of pregnancies), and linkage of hospitalisations during and following pregnancy. For this study, rates of missed and incorrect links were less than 0.5%.

Postpartum haemorrhage was identified from the hospital data using ICD codes (O72). Blood loss of equal or greater than 500mL following a vaginal birth, or equal or greater than 750mL following a caesarean birth is classified as a postpartum haemorrhage [10]. Validation studies have indicated that postpartum haemorrhage is accurately reported, although under-enumerated with sensitivity and specificity of 73.8% and 98.9%, respectively.[11] Previous postpartum haemorrhage was defined as a postpartum haemorrhage reported in any previous pregnancy (since July 2001) and was obtained from the longitudinal linkage of a woman's pregnancies.

Outcomes of interest were severe maternal morbidity and blood transfusion. Maternal morbidity was measured using a validated composite indicator of adverse outcomes.[12] This indicator includes diagnoses such as shock, uterine rupture, and cerebrovascular accident as well as procedures including assisted ventilation, dialysis, evacuation of haematoma, hysterectomy, dilatation and curettage under general anaesthesia, and embolisation or ligation of blood vessels. The original indicator included blood transfusion as a component of morbidity, however this was excluded from the criteria for morbidity for this study. Use of a composite indicator overcomes the under-ascertainment of individual diagnoses and procedures.[13] Blood transfusion was defined in this study as transfusion of whole blood or red blood cells (ACHI 13706-01, 13706-02)[9], which is well reported (sensitivity and specificity of 83.1% and 99.9%, respectively).[11] Since we were interested in trends in transfusion and morbidity, women experiencing both a transfusion and a morbidity diagnosis were included in both the transfusion and morbidity outcomes. A sensitivity analysis was performed to assess whether estimates changed when transfusion and morbidity were treated as mutually exclusive outcomes.

Maternal demographics, pregnancy, labour and delivery data were obtained from the birth data; chronic conditions (chronic hypertension, diabetes, renal and cardiac conditions), antepartum haemorrhage (APH), morbidly adherent placenta, and placenta praevia were obtained from the hospital data; and pregnancy hypertension and gestational diabetes were obtained from either birth or hospital data based on validation studies indicating the most reliably reported sources. [11,14-17]

Trends were calculated on the whole population, and among subgroups, and tested using the Cochran Armitage test for trend. Logistic regression models were developed to assess the change in severity of postpartum haemorrhage over time among birth admissions for women delivering a singleton infant. Models were developed separately for vaginal and caesarean births, and for maternal morbidity and transfusion. Factors which were significant in a univariate model at alpha 0.3 were entered into the initial multivariable model, and progressively removed until only factors significant at alpha 0.05 remained. Year and maternal age were retained in all models, and variables considered confounders if estimates changed more than 10% on their removal. A sensitivity analysis was also performed including diagnosis codes for placenta praevia with haemorrhage as part of the definition of a postpartum haemorrhage, however associations were unchanged so this analysis has not been included. All analysis was conducted in SAS 9.3. Ethics approval was from the NSW Population and Health Services Research Ethics Committee.

Results

Between 2003 and 2011 there were 818,965 births in New South Wales. Overall, a postpartum haemorrhage was reported in 59,639 (7.3%) of births. There was a significant increase in the postpartum haemorrhage rate, from 6.1% (n=5158) in 2003 to 8.3% (n=7886) in 2011 ($p<0.0001$). Among caesarean births, the rate of postpartum haemorrhage increased by 55% (3.7% to 5.7%), whereas among vaginal births they increased by 36% (7.0% to 9.5%) (Figure 1 and 2). Women with a postpartum haemorrhage were more likely to have multifetal pregnancies, be primiparous, have pregnancy hypertension, antepartum haemorrhage, instrumental delivery and large-for-gestational age infants, and were less likely to be a private patient. Women with a previous postpartum haemorrhage

were more likely to have a postpartum haemorrhage in the current pregnancy than women without a history of postpartum haemorrhage (Table 1).

Subsequent morbidity among women with a postpartum haemorrhage

There was no significant change in the crude maternal morbidity rate (excluding transfusion) among women with a postpartum haemorrhage (p=0.28) (2.9 per 100 births to 2.8 per 100 births). Having accounted for maternal and pregnancy factors, there was no significant increase in morbidity among women with a PPH delivering vaginally (aOR for yearly change 0.97 (0.94-1.00); p=0.36), and a slight decrease among women delivering by caesarean section (aOR 0.96 (0.92-0.99); p<0.01) (Table 2).

Risk factors for maternal morbidity among women were similar for those giving birth vaginally and by caesarean section. These risk factors included advanced maternal age (>35 years), women with chronic conditions, maternal birth outside Australia, preterm birth, placenta praevia, morbidly adherent placenta, pregnancy hypertension, and women with a history of postpartum haemorrhage. Instrumental deliveries were associated with higher morbidity among vaginal births (Table 2).

Transfusion among women with a postpartum haemorrhage

There was a significant increase in the red cell transfusion rate (p<0.001) among women with a postpartum haemorrhage from 12.3 per 100 births in 2003 to 14.5 per 100 births in 2011. After adjustment for other risk factors, there was a significant increase in transfusions for vaginal births (aOR 1.02 (1.00-1.03); p<0.01), however there was no significant trend amongst caesarean births (aOR 0.99 (0.97-1.01); p=0.30) (Table 3). Risk factors for blood transfusion following postpartum haemorrhage included the extremes of maternal age, preterm birth, morbidly adherent placenta, placenta praevia, antepartum haemorrhage, induction of labour, previous postpartum haemorrhage, and delivery in a regional hospital. For vaginal deliveries, instrumental births, pregnancy hypertension, smoking and previous caesarean section were also risk factors. For caesarean births, higher parity was associated with increased risk of transfusion (Table 3)

A sensitivity analysis (data not shown) was performed in which women experiencing both a transfusion and morbidity (n=925) were only included in the morbidity outcome. The increase in blood transfusion persisted but was slightly attenuated (10.7 to 12.7; $p<0.001$). The adjusted morbidity and transfusion trends were unchanged.

Discussion

This population-based study indicates that while the postpartum haemorrhage rate has continued to rise, there has been no increase in maternal morbidity. However, the rate of transfusion associated with haemorrhage has increased slightly over the study period. We found not only had postpartum haemorrhage rates increased between 2003 and 2011, but that the increase over this 9 year period was proportionally higher than previously reported [18](36% increase compared to 25% in the previous 8 year period). Although the population burden of postpartum haemorrhage is among vaginal births, the increase in the postpartum haemorrhage rate was primarily driven by haemorrhage post-caesarean birth.

Despite known under-ascertainment of postpartum haemorrhage for women delivered by caesarean section,[19] there are no known reporting changes over the study period. Other studies reporting increases in overall postpartum haemorrhage have not stratified by mode of delivery so it is unknown whether this trend is mirrored in other settings.[1,20] A recent Canadian paper suggested that post-caesarean atonic haemorrhages increased by 95% from 2001 to 2009 while post-vaginal delivery atonic haemorrhages increased by 35%.[3] It is possible that bleeding post-caesarean that would previously not been classified as postpartum haemorrhage (vaginal/ vulvular haematomas, uterine cavity bleeding post-closure or bleeding masked by drapes or dressings) may be being incorporated into more recent measures of postpartum haemorrhage. We have previously demonstrated misclassification of reporting on PPH cause using ICD reporting, in particular over-estimation of the contribution of uterine atony to PPH.[21] There are no known practice changes associated with caesarean delivery over this period that explain increased haemorrhage rates.

Reassuringly, morbidity rates post-haemorrhage do not appear to have increased, and among caesarean deliveries decreased over the study period. This suggests that the increase in postpartum haemorrhage does not represent an increase in severe haemorrhage resulting in life-threatening complications. While more postpartum haemorrhages have been identified, the management of these may be preventing deterioration into severe morbidity. Previously, postpartum haemorrhage was reported to be driving up rates of maternal morbidity in Australia[13]; importantly, this previous study included transfusion as part of the composite measure of maternal morbidity, whereas for the current study we have investigated transfusion separately.

After adjustment for other risk factors, there was a significant increase in red cell transfusions for vaginal births, however there was no significant trend among caesarean births. Given that the increase among vaginal births occurred in the context of no increase in morbidity, this may reflect an increased frequency of use of red cell transfusion for less severe cases of haemorrhage post-vaginal delivery. The proportion of women with postpartum haemorrhage receiving transfusion had previously increased dramatically (from 2% in 1994 to 12% in 2002).[5] Our study suggests that a higher proportion of women are now transfused (12% in 2003 to 15% in 2011), however, the rate of increase is much less than previously demonstrated. Without details on actual blood loss or timing of transfusion (immediately post-delivery or a few days postpartum) it is difficult to speculate about the severity of haemorrhages being transfused. Nevertheless, in the setting of increased obstetric transfusions[2] and the largely unpredictable nature of postpartum haemorrhage, patient blood management strategies including recognizing and treating antepartum anemia, active management of the third stage of labour and use of iron therapy in the setting of postpartum anemia are worthwhile considering for pregnant and recently pregnant women.

While preterm birth and the presence of chronic conditions increased the risk of morbidity following postpartum haemorrhage, even when these factors were taken into account, women with a previous caesarean birth or previous birth complicated by postpartum haemorrhage remained at increased risk

of subsequent morbidity. The role previous birth complications play in index birth complications is increasingly being recognised[22,23] and underlines the importance of recording and taking into account obstetric history when caring for multiparous women.

Strengths of this study include the use of validated population-based data to investigate rare outcomes including severe adverse maternal outcomes and transfusion as well as the incorporation of previous obstetric history. Using record linkage we have been able to take into account previous postpartum haemorrhage and previous caesarean, although for the earlier years of the study only a two year lookback period was available. The two outcomes considered in this study may be inter-related –a transfusion in some cases is likely to prevent further morbidity.

Conclusions

While women giving birth today are more likely to have a postpartum haemorrhage, on the whole they are no more likely to experience adverse outcomes subsequent to the haemorrhage than in 2003. The increase in post-caesarean haemorrhage highlights the need for vigilance in the operative setting. The marginal increase in red cell transfusions following vaginal birth postpartum haemorrhage warrants further investigation. The increase in PPH may represent fewer severe haemorrhages, well-managed haemorrhage or better recording of PPH; the increase in transfusions following postpartum haemorrhage may indicate changes in management of third stage of labour. Further insight into the severity of postpartum haemorrhages in the Australian setting will soon be available via record linkage that allows number of units transfused to each woman to be assessed.

Acknowledgements

The authors thank the NSW Ministry of Health for access to the population health data (birth and hospital) and the NSW Centre for Health Record Linkage for linking the data sets. This work was supported by an Australian National Health and Medical Research Council (NHMRC) Partnership Grant (#1027262). CR is supported by an NHMRC Senior Research Fellowship (#APP1021025) and

JF is supported by an Australian Research Council Future Fellowship (#FT120100069). The funding agencies listed had no role in protocol design, decision to publish, or preparation of the manuscript.

Contribution

JF and CR conceived and designed the study. JP undertook the analysis and all authors were involved in interpretation, drafting the manuscript and critically revising the content.

References

1. Knight M, Callaghan WM, Berg C, Alexander S, Bouvier-Colle MH, Ford JB, Joseph KS, Lewis G, Liston RM, Roberts CL *et al*: **Trends in postpartum hemorrhage in high resource countries: a review and recommendations from the International Postpartum Hemorrhage Collaborative Group.** *BMC Pregnancy Childbirth* 2009, **9**:55.
2. Patterson J, Roberts C, Bowen J, Irving D, Isbister J, Morris J, Ford J: **Obstetric blood transfusion during pregnancy, birth and the postnatal period: a population based study.** *Obstet Gynecol* 2014, **123**(1):126-133.
3. Mehrabadi A, Hutcheon JA, Lee L, Liston RM, Joseph KS: **Trends in postpartum hemorrhage from 2000 to 2009: a population-based study.** *BMC Pregnancy Childbirth* 2012, **12**:108.
4. Callaghan WM, MacKay AP, Berg CJ: **Identification of severe maternal morbidity during delivery hospitalizations, United States, 1991-2003.** *Am J Obstet Gynecol* 2008, **199**(2):133.e131-133.e138.
5. Cameron CA, Roberts CL, Olive EC, Ford JB, Fischer W: **Trends in postpartum haemorrhage.** *Aust N Z J Public Health* 2006, **30**(2):151-156.
6. Combs CA, Murphy EL, Laros RK: **Factors associated with postpartum hemorrhage with vaginal birth.** *Obstet Gynecol* 1991, **77**(1):69-76.
7. Combs CA, Murphy EL, Laros RK: **Factors associated with haemorrhage in cesarean deliveries.** *Obstet Gynecol* 1991, **77**(1):77-82.
8. National Centre for Classification in Health: **The International Statistics Classification of Diseases and Related Health Problems, tenth revision, Australian modification.** Sydney: National Centre for Classification in Health, University of Sydney; 2004.
9. National Centre for Classification in Health.**The Australian Classification of Health Interventions**; 2006. Sydney:
10. National Centre for Classification in Health: **Australian coding standards for ICD-10-AM and ACHI**. Sydney: National Centre for Classification in Health; 2006.
11. Lain SJ, Roberts CL, Hadfield RM, Bell JC, Morris JM: **How accurate is the reporting of obstetric haemorrhage in hospital discharge data? A validation study.** *Aust N Z J Obstet Gynaecol* 2008, **48**(5):481-484.
12. Roberts CL, Cameron CA, Bell JC, Algert CS, Morris JM: **Measuring maternal morbidity in routinely collected health data: development and validation of a maternal morbidity outcome indicator.** *Med Care* 2008, **46**(8):786-794.
13. Roberts CL, Ford JB, Algert CS, Bell JC, Simpson JM, Morris JM: **Trends in adverse maternal outcomes during childbirth: a population-based study of severe maternal morbidity.** *BMC Pregnancy Childbirth* 2009, **9**:7.
14. Roberts C L, Bell J C, Ford J B, Morris J M: **Monitoring the quality of maternity care: how well are labour and delivery events reported in population health data?** *Paediatr Perinat Epidemiol* 2009, **23**:144-152.

15. Roberts C L, Bell J C, Ford J B, Hadfield R, M. MJ: **The accuracy of reporting of hypertensive disorders of pregnancy in population health data.** *Hypertension in Pregnancy* 2008, **27**(3):285-297.
16. Hadfield RM, Lain SJ, Cameron CA, Bell JC, Morris JM, Roberts CL: **The prevalence of maternal medical conditions during pregnancy and a validation of their reporting in hospital discharge data.** *Aust N Z J Obstet Gynaecol* 2008, **48**(1):78-82.
17. Bell JC, Ford JB, Cameron CA, Roberts CL: **The accuracy of population health data for monitoring trends and outcomes among women with diabetes in pregnancy.** *Diabetes Res Clin Pract* 2008, **81**(1):105-109.
18. Ford JB, Roberts CL, Simpson JM, Vaughan J, Cameron CA: **Increased postpartum hemorrhage rates in Australia.** *Int J Gynaecol Obstet* 2007, **98**(3):237-243.
19. Roberts CL, Ford JB, Thompson J, JM. M: **Population rates of haemorrhage and transfusions among obstetric patients (letter).** *Aust N Z J Obstet Gynaecol* 2009, **49**:296-298.
20. Joseph KS, Rouleau J, Kramer M, Young DC, Liston RM, Baskett TF, System ftMHSGotCPS: **Investigation of an increase in postpartum haemorrhage in Canada.** *BJOG: an International Journal of Obstetrics & Gynaecology* 2007(DOI: 10.1111/j.1471-0528.2007.01316.x).
21. Ford JB, Algert CS, Kok C, Choy MA, Roberts CL: **Hospital data reporting on postpartum hemorrhage: under-estimates recurrence and over-estimates the contribution of uterine atony.** *Matern Child Health J* 2012, **16**(7):1542-1548.
22. Oberg AS, Hernandez-Diaz S, Palmsten K, Almqvist C, Bateman BT: **Patterns of recurrence of postpartum hemorrhage in a large population-based cohort.** *Am J Obstet Gynecol* 2014, **210**(3):229 e221-228.
23. Ford JB, Roberts CL, Bell JC, Algert CS, Morris J: **Postpartum haemorrhage occurrence and recurrence: a population-based study.** *Med J Aust* 2007, **187**(7):391-393.

Table 1 Maternal and pregnancy characteristics of women with and without postpartum haemorrhage (PPH), NSW, 2003-2011

Variable	PPH (N=59,639)	No PPH (N=759,326)
Maternal age		
Under 20	2386 (4.0)	27407 (3.6)
20-34	45012 (75.5)	562067 (74.0)
35+	12241 (20.5)	169852 (22.4)
Smoker	6524 (10.9)	88992 (11.7)
Australian born	38530 (64.6)	523266 (68.9)
Multiple birth	1647 (2.8)	10927 (1.4)
Parity		
1st	29179 (48.9)	317620 (41.8)
2nd-4th	28021 (47.0)	412846 (54.4)
5+	2366 (4.0)	27588 (3.6)
Previous Caesarean	5489 (9.2)	111610 (14.7)
Gestational diabetes	3842 (6.4)	45688 (6.0)
Pregnancy hypertension	6740 (11.3)	69387 (9.1)
Antepartum haemorrhage	2440 (4.1)	19246 (2.5)
Malpresentation	2037 (3.4)	35981 (4.7)
Previous PPH	10823 (18.1)	27116 (3.6)
Placenta praevia	1253 (2.1)	7678 (1.0)
Morbidly adherent placenta	1163 (2.0)	826 (0.1)
Gestational age		
20-32 weeks	1372 (2.3)	11654 (1.5)
33-36 weeks	3023 (5.1)	37969 (5.0)
37+ weeks	55244 (92.6)	709703 (93.5)
Mode of birth		
Normal vaginal delivery	36717 (61.6)	451652 (59.5)
Caesarean	11860 (19.9)	228010 (30.0)
Caesarean without labour	5465 (9.2)	133292 (17.6)
Caesarean with labour	6393 (10.7)	94704 (12.5)
Instrumental delivery	11186 (18.8)	80382 (10.6)
Forceps	4802 (8.1)	26272 (3.5)
Vacuum	6384 (10.7)	54110 (7.1)
Induction	20479 (34.3)	202866 (26.7)
Large for gestational age	9197 (15.4)	78804 (10.4)
Hospital type		
Tertiary	31503 (52.8)	307664 (40.5)
Regional	11561 (19.4)	161522 (21.3)
Urban/other	8754 (14.7)	99859 (13.2)
Private	7821 (13.1)	190281 (25.1)

Table 2 Risk factors for *maternal morbidity* among women with a postpartum haemorrhage, NSW, 2003-2011.

	Vaginal births N=46955					Caesarean births N=11037				
	Univariate			Multivariate		Univariate			Multivariate	
	Odds ratio	**95% CI**	**P**	**Odds Ratio**	**95% CI**	**Odds ratio**	**95% CI**	**P**	**Odds ratio**	**95% CI**
Maternal Age										
Under 20	1.01	(0.72, 1.42)		**1.10**	**(0.78, 1.56)**	0.27	(0.10, 0.72)		**0.38**	**(0.14, 1.04)**
20-34	Ref					Ref				
35+	1.42	(1.21, 1.67)	<0.0001	**1.24**	**(1.05, 1.47)**	1.45	(1.23, 1.70)	<0.0001	**1.20**	**(1.00, 1.42)**
Private patient	0.92	(0.78, 1.09)	0.33	.		1.12	(0.93, 1.35)	0.22	.	
Smoker	1.04	(0.85, 1.30)	0.67	.		1.35	(1.09, 1.69)	<0.01	.	
Parity										
1	Ref					Ref				
2-4	0.95	(0.83, 1.09)	0.42	.		1.93	(1.62, 2.29)	<0.0001	.	
5+	1.18	(0.84, 1.64)		.		3.21	(2.37, 4.34)		.	
Australian born	0.84	(0.73, 0.96)	0.01	**0.81**	**(0.70, 0.94)**	0.86	(0.74, 1.01)	0.07	**0.77**	**(0.65, 0.92)**
Gestational Age										
20-32	4.36	(3.25, 5.84)	<0.0001	**2.59**	**(1.76, 3.82)**	3.63	(2.74, 4.80)	<0.0001	**2.22**	**(1.61, 3.07)**
33-36			Ref					Ref		
37+	1.58	(1.16, 2.17)		**1.29**	**(0.93, 1.79)**	2.84	(2.29, 3.52)		**1.52**	**(1.17, 1.97)**
Mode of birth										
Vaginal		Ref								
Forceps	1.22	(0.98, 1.51)	0.12						.	
Vacuum	1.14	(0.94, 1.39)							.	
Caesarean in labour						0.80	(0.68, 0.93)	<0.01	**1.76**	**(1.45, 2.13)**
Pre-labour caesarean						Ref				
Induction	1.18	(1.03, 1.36)	0.03	.		0.80	(0.67, 0.96)	0.02		
Large for gestational age	0.83	(0.67, 1.02)	0.07	.		0.73	(0.59, 0.90)	<0.01	.	
Chronic conditions	3.64	(2.63, 5.03)	<0.0001	**2.90**	**(2.06, 4.08)**	2.04	(1.47, 2.85)	<0.0001	**2.08**	**(1.46, 2.96)**

Pregnancy factors										
Antepartum haemorrhage	1.76	(1.30, 2.38)	<0.0001	.		1.60	(1.25, 2.05)	<0.0001	.	
Previous caesarean	1.79	(1.38, 2.31)	<0.0001	**1.62**	**(1.24, 2.13)**	2.18	(1.86, 2.55)	<0.0001	**2.00**	**(1.66, 2.40)**
Previous PPH	1.5	(1.28, 1.76)	<0.0001	**1.41**	**(1.20, 1.65)**	2.35	(1.99, 2.79)	<0.0001	**1.75**	**(1.45, 2.12)**
Malpresentation	4.22	(2.88, 6.20)	<0.0001	.		1.30	(1.05, 1.62)	0.02	**.**	
Morbidly adherent placenta	4.96	(3.81, 6.47)	<0.0001	**4.24**	**(3.20, 5.61)**	17.45	(13.81, 22.05)	<0.0001	**10.33**	**(7.89, 13.51)**
Placenta praevia						3.97	(3.29, 4.78)	<0.0001	**2.30**	**(1.79, 2.95)**
Gestational diabetes	1.22	(0.94, 1.59)	0.14	.		1.02	(0.78, 1.34)	0.88	.	
Pregnancy hypertension	1.63	(1.35, 1.97)	<0.0001	**1.66**	**(1.35, 2.04)**	1.42	(1.16, 1.73)	<0.01	**1.55**	**(1.24, 1.94)**
Year of birth										
1 year increments	0.99	(0.96, 1.02)	0.40	0.99	(0.96, 1.01)	0.97	(0.94, 1.00)	0.07	**0.96**	**(0.92, 0.99)**
Hospital										
Tertiary		Ref							Ref	
Urban	1.02	(0.84, 1.24)		.		0.75	(0.58, 0.98)		.	
Regional	0.98	(0.74, 1.17)		.		0.88	(0.70, 1.10)		.	
Private	0.91	(0.74, 1.14)	0.81	.		1.03	(0.80, 1.30)	0.13	.	

Numbers in bold represent statistically significant adjusted risk or protective factors for maternal morbidity. Chronic conditions included chronic hypertension, pre-existing diabetes, renal disease, cardiac disease.

Table 3 Risk factors for *red cell blood transfusion* among women with a postpartum haemorrhage, NSW, 2003-2011.

	Vaginal births N=46955					Caesarean births N=11037				
	Univariate			Multivariate		Univariate			Multivariate	
	Odds ratio	**95% CI**	**P**	**Odds ratio**	**95% CI**	**Odds ratio**	**95% CI**	**P**	**Odds ratio**	**95% CI**
Maternal Age										
Under 20	1.46	(1.29, 1.64)		**1.26**	**(1.11, 1.43)**	1.67	(1.25, 2.23)		**2.04**	**(1.52, 2.75)**
20-34	Ref					Ref				
35+	1.09	(1.01, 1.17)	<0.0001	**1.14**	**(1.06, 1.23)**	1.32	(1.19, 1.46)	<0.0001	**1.08**	**(0.97, 1.21)**
Private patient	0.81	(0.76, 0.87)	<0.0001	**0.88**	**(0.79, 0.97)**	1.12	(1.00, 1.26)	0.06	**.**	
Smoker	1.21	(1.12, 1.31)	<0.0001	**1.16**	**(1.07, 1.26)**	1.2	(1.00, 1.35)	0.05	**.**	
Parity										
1	0.76	(0.72, 0.81)	<0.0001	**0.80**	**(0.74, 0.85)**	1.27	(1.15, 1.41)	<0.0001	**1.18**	**(1.05, 1.32)**
2-4	Ref			**Ref**		Ref				
5+	0.96	(0.83, 1.11)		**0.85**	**(0.73, 0.99)**	2.54	(2.07, 3.11)		**2.06**	**(1.65, 2.57)**
Australian born	1.03	(0.98, 1.09)	0.27	**.**		0.86	(0.78, 0.95)	<0.01	**0.74**	**(0.66, 0.83)**
Gestational Age										
20-32	1.49	(1.22, 1.81)	<0.0001	**1.36**	**(1.08, 1.72)**	2.56	(2.07, 3.17)	<0.0001	**1.79**	**(1.40, 2.29)**
33-36	1.54	(1.35, 1.76)		**1.45**	**(1.26, 1.66)**	1.74	(1.48, 2.04)		**1.07**	**(0.89, 1.29)**
37+	Ref					Ref				
Mode of birth										
Vaginal	Ref									
Forceps	1.75	(1.61, 1.90)	<0.0001	**1.69**	**(1.54, 1.84)**					
Vacuum	1.34	(1.24, 1.45)		**1.31**	**(1.20, 1.43)**					
Caesarean in labour						0.97	(0.88, 1.07)	0.54	**.**	
Pre-labour caesarean						Ref				
Induction	1.18	(1.12, 1.25)	<0.0001	**1.13**	**(1.06, 1.19)**	0.87	(0.77, 0.97)	0.01	**1.25**	**(1.10, 1.42)**
Large for gestational age	1.06	(0.98, 1.15)	0.13	**.**		1.00	(0.89, 1.13)	0.98	**.**	
Chronic conditions	1.46	(1.19, 1.80)	<0.0001	**1.28**	**(1.04, 1.58)**	1.18	(0.91, 1.52)	0.22	**.**	
Pregnancy factors										

Antepartum haemorrhage	1.64	(1.43, 1.88)	<0.0001	**1.48**	**(1.28, 1.70)**	1.81	(1.55, 2.13)	<0.0001	**1.47**	**(1.24, 1.76)**
Previous caesarean	1.27	(1.12, 1.44)	<0.0001	**1.41**	**(1.23, 1.60)**	1.17	(1.05, 1.30)	<0.01	**.**	
Previous PPH	1.36	(1.27, 1.46)	<0.0001	**1.41**	**(1.32, 1.52)**	1.56	(1.39, 1.76)	<0.0001	**1.28**	**(1.13, 1.45)**
Malpresentation	1.35	(1.03, 1.76)	0.03	**.**		1.17	(1.01, 1.34)	0.04	**.**	
Morbidly adherent placenta	3.83	(3.30, 4.44)	<0.0001	**.**		7.92	(6.31, 9.94)	<0.0001	**5.03**	**(3.94, 6.42)**
Placenta praevia				**.**		3.53	(3.08, 4.05)	<0.0001	**2.63**	**(2.25, 3.07)**
Gestational diabetes	1.05	(0.93, 1.18)	0.45	**.**		0.92	(0.77, 1.10)	0.38	**.**	
Pregnancy hypertension	1.50	(1.38, 1.63)	<0.0001	**1.37**	**(1.26, 1.49)**	1.01	(0.88, 1.16)	0.89	**.**	
Year of birth										
1 year increments	1.03	(1.02, 1.04)	<0.0001	**1.02**	**(1.01, 1.03)**	1.00	(0.98, 1.02)	0.83	0.99	(0.97, 1.01)
Hospital										
Tertiary	Ref					Ref				
Urban	0.95	(0.88, 1.03)		**1.06**	**(0.97, 1.15)**	0.91	(0.77, 1.06)		**1.02**	**(0.87, 1.20)**
Regional	1.22	(1.14, 1.31)		**1.28**	**(1.20, 1.38)**	1.25	(1.10, 1.43)		**1.54**	**(1.33, 1.78)**
Private	0.78	(0.71, 0.86)	<0.0001	**0.88**	**(0.77, 1.01)**	1.3	(1.11, 1.51)	<0.0001	**1.46**	**(1.24, 1.72)**

Numbers in bold represent statistically significant adjusted risk or protective factors for transfusion. Chronic conditions included chronic hypertension, pre-existing diabetes, renal disease, cardiac disease.

Figure 1: Trends in postpartum haemorrhage, adverse maternal outcomes (MMOI) and red cell transfusion rates among vaginal births in NSW, 2003-2011.

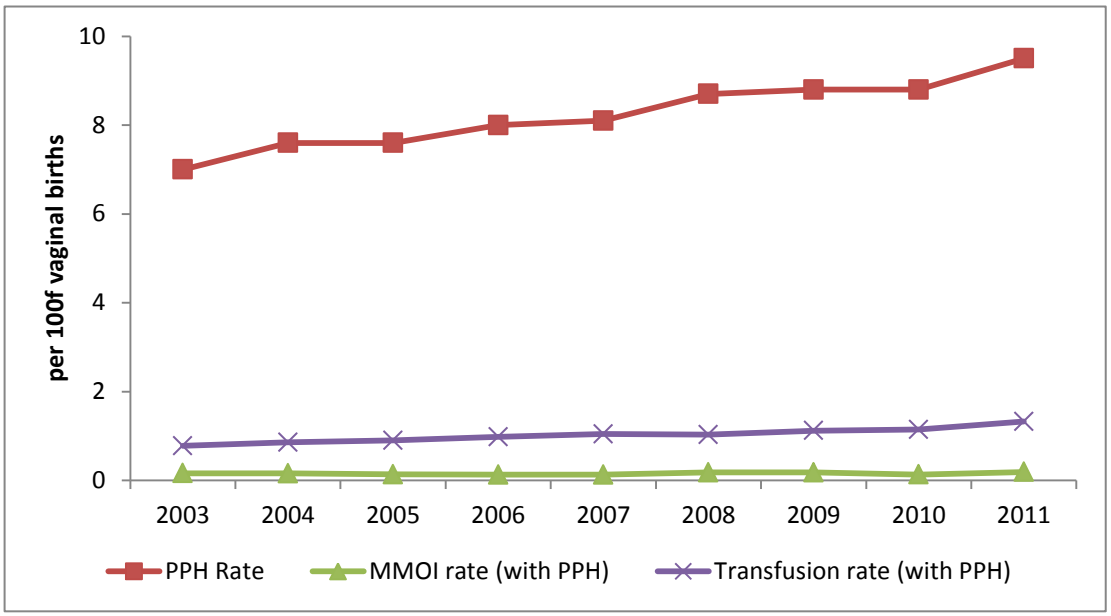

Figure 2: Trends in postpartum haemorrhage, adverse maternal outcomes (MMOI) and red cell transfusion rates among caesarean section births in NSW, 2003-2011.