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Blood transfusion during pregnancy, birth and the postnatal period: a population based study

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Precis: Obstetric blood transfusions continue to increase, with most of these occurring in the birth admission in association with hemorrhage.

Objectives: To identify trends in transfusion rates across pregnancy and the postnatal period, and identify risk factors for transfusion.

Methods: Linked hospital and birth data on all births in hospitals in New South Wales, Australia between 2001 and 2010 were used to identify blood transfusions for women during pregnancy, at birth and in the 6 weeks post partum. Poisson regression was used to identify risk factors for red cell transfusion in the birth admission. Separate models were fitted for cesarean and vaginal births.

Results: Between 2001 and 2010 there were 12147 transfusions across 891,914 pregnancies, with a transfusion rate of 1.4%. The transfusion rate increased steadily from 1.2% in 2001 to 1.6% in 2010. The majority of transfusions (91%) occurred during the birth admission, and 81% of these transfusions were associated with a diagnosis of hemorrhage. Women with bleeding/platelet disorders(vaginal RR= 7.8, CI 7.1-8.5, cesarean RR 8.7, CI 7.9-9.5) and placenta previa(vaginal RR=4.6, CI 3.7-5.8, cesarean 5.7, CI 5.2-6.2), were at highest risk of transfusion. Among vaginal births, increased risk was evident for forceps (RR=2.8, CI 2.6-3.0) or vacuum births (RR=1.9, CI 1.7-2.0) compared with non-operative births.

Conclusions: Rates of obstetric blood product transfusion have increased by 33% since 2001, with the majority of this associated with hemorrhage. Women with bleeding/platelet disorders and placenta previa are at increased risk of transfusion, and should be managed accordingly.

Introduction

Blood transfusion, as applies to any therapy, should be used judiciously and appropriately to ensure optimal patient outcomes. Blood is a limited, costly resource with transfusion of it or any of its products associated with specific risks.(1, 2) Internationally, this has lead to increased efforts to reduce unnecessary blood use across many disciplines.(3) Transfusion of red blood cells generally has decreased in Australia in recent years,(4) however there is evidence of increasing rates of maternal red blood cell transfusion around childbirth.(5) This trend has also been observed in the USA, Canada, Finland, and the Republic of Ireland, particularly in the context of postpartum hemorrhage (PPH).(6-11) The obstetric blood transfusion rate in New South Wales (NSW), Australia in 2002 was 0.9%, which was higher than contemporaneous rates reported in other countries, including the USA (0.46% in 2003),(7) Canada (0.63% in 2004)(12) and Ireland (0.84% in 2003).(11) Reasons for the higher rate are unknown, although may relate to differences in data collection. While for many surgical procedures, high risk of transfusion is known in advance, and measures to minimize the risk of transfusion can be taken, this is rarely the case in obstetrics, where transfusions tend to be urgent, unpredictable, and in otherwise healthy women.(13)

A small number of population based studies have identified risk factors for blood transfusion in the maternity setting. Important risk factors include mode of delivery, placenta previa, antepartum hemorrhage, anemia, multiple pregnancies, and the extremes of maternal age.(10, 14, 15) Population data collected in administrative datasets provide a valuable source of data for such studies, allowing examination of trends and risk factors in uncommon outcomes such as transfusion.(16) These studies typically look only at the birth admission, and so are unable to estimate the transfusion burden associated with antenatal and postpartum hospitalizations. Few studies have considered blood products other than red cells.

This study aims to explore recent trends in blood and blood product transfusion, and the use of blood products throughout pregnancy and the postnatal period in women whose pregnancy

ended in a registered birth (beyond 20 weeks gestation). We also examine the risk factors for transfusion during the birth admission.

Materials and Methods

The study population included women giving birth in NSW hospitals between January 2001 and December 2010. NSW is the most populous state in Australia, with over 7 million residents and approximately 90,000 births per annum. 'Birth data' including maternal characteristics, pregnancy and birth were obtained from the Perinatal Data Collection (PDC). The PDC is a statutory population based collection of all births in NSW of at least 20 weeks gestation or 400 grams birthweight. These data were linked to 'hospital data' from the Admitted Patients Data Collection (APDC). The APDC is a census of all public and private hospital separations in NSW, and records information on diagnoses and procedures associated with these separations. Up to 20 of the 55 available diagnoses and procedures for each separation are coded according to the 10th revision of the International Classification of Diseases, Australian Modification (ICD-10-AM) and the Australian Classification of Health Interventions (ACHI). The NSW Centre for Health Record Linkage performed probabilistic data linkage between the two data sets. For this study, rates of incorrect and missed links were less than 5 per 1000.

Hospital admissions were classified as antenatal, birth or postnatal, to allow for examination of the different blood product usage at each stage of pregnancy. Antenatal admissions were those that occurred from 20 weeks gestation and ended with the mother being discharged prior to the birth. Birth admissions were separated into those with a prolonged antenatal component (>4 days), and those admitted 4 days or less before birth. Postnatal admissions were admissions occurring after the initial discharge of the mother, but within 6 weeks of the birth. Admissions involving transfusion of blood products were identified from the hospital data, using ACHI procedure codes.(17) 'Blood transfusion' refers to the administration of packed red cells or whole blood, and 'Platelets and coagulation factors' includes platelets,

coagulation factors, and other serum (including fresh frozen plasma), 'Blood products' is used to refer to transfusion of either or both of these. Blood transfusion and administration of platelets and coagulation factors are well ascertained in the hospital data, with sensitivities and specificities of 83.1%, 99.9% and 73.1%, 100% respectively.(16) The quality of reporting of use of other blood derived products (including leukocytes, gamma globulin) is unknown and so use of these products was not considered. Women with iron deficiency anemia were identified from the hospital data and women with bleeding or platelet disorders were identified by ICD-10-AM codes for conditions such as thalassemia, hemolytic and aplastic anemias, coagulation defects, and idiopathic thrombocytopenic purpura (Appendix 1). Antepartum hemorrhage (APH) included placental abruption or other antepartum hemorrhage. Women without bleeding disorders, APH, placenta previa, hypertension and diabetes were considered to have no prior indication for transfusions. Age and gestational age groups were determined based on clinical relevance and women were classified as private patients if they received private obstetric care in a public or private hospital.

Rates were calculated per 100,000 pregnancies and proportions are proportion of pregnancies, unless otherwise specified. Multiple births (twins or higher order multiples) were counted as a single pregnancy. Trends were assessed using the Cochran Armitage test for trend. A multivariable Poisson regression model with robust variances was used to identify factors associated with higher use of blood product transfusions; factors which were significant with alpha 0.2 in a univariate model were included in the initial multivariable model, and removed in a stepwise fashion until only variables significant at alpha 0.05 remained. This was performed separately for vaginal and cesarean births to account for possible differences in decision making based on physical location (operating theatre versus birth unit), and differing criteria for PPH (a common indication for blood transfusion). In the ICD-10-AM PPH is defined as blood loss of 750mL or more following cesarean section, or ≥500mL following vaginal birth.(18) Women with missing data on possible confounders were excluded from this analysis. All analyses were performed in SAS 9.3. Ethical approval

was obtained from the NSW Population and Health Services Research Ethics Committee.

Results

In the period 2001-2010, there were 891,914 pregnancies to 578,207 women, involving 1,117,939 admissions. The blood product transfusion rate was 1.4% of pregnancies, with 11,529 mothers receiving a transfusion in 12,147 pregnancies or the postnatal period. During the time period, 286 women had more than one pregnancy involving a transfusion, including 50 (17%) women with a bleeding disorder. Blood products were transfused in 484 antenatal admissions, 667 prolonged birth admissions, 10,715 birth and 600 postnatal admissions. The transfusion rate was highest for the birth admission (1201 per 100,000 pregnancies), compared with the antenatal (54 per 100,000 pregnancies), prolonged birth admissions (75 per 100,000 pregnancies) and postnatal admissions (67 per 100,000 pregnancies). Ninety-one percent (11382) of transfusions occurred in the birth admission, while 3.9% were antenatal and 4.8% were postnatal transfusions.

The transfusion of blood products at any stage during pregnancy, birth or the postnatal period increased steadily from 1174 per 100,000 in 2001 to 1634 per 100,000 in 2010 ($p=<0.001$) (Figure 1). When considering only the birth admission, the rate increased from 1101 per 100,000 in 2001 to 1532 per 100,000 in 2010 ($p<0.001$). There has been little change in the type of products used, with the majority of women (86%) receiving only packed red cells and/or whole blood; packed cells making up the majority of this (99.4%).

When compared with red cell use, platelets and coagulation factors were more commonly used among women aged 35 and older, private patients, multiparous women and those having a cesarean birth (Table 1). Where blood product transfusion occurred during pregnancy, this usually occurred in a single admission (98.6%), with less than 0.4% of pregnancies involving 3 or more admissions involving transfusions.

Rates of transfusion in the birth and postnatal period were high in women having a hysterectomy in the birth admission (89619 per 100,000 such pregnancies, N= 439), where

blood products had been transfused antenatally (18750 per 100,000, N=63), and where a PPH occurred in the birth admission (13528 per 100,000, N=8388). In women with no prior indication, the transfusion rate was 953 per 100,000 pregnancies (N=6927). Among birth admissions with <4 days antenatal stay involving transfusion, 80.8% included a hemorrhage diagnosis. Women who received transfusions in birth or postnatal admission were in hospital longer than those who did not (median days (IQR) birth 5 (4,7) vs 3 (2,5), postnatal 3 (2,5) vs 2 (0,3)).

Full data on possible confounders were available for 885,389 pregnancies (99.3%) and were included in our risk factor analysis. Overall, after adjusting for maternal factors, forceps delivery was associated with the highest risk of transfusion of all modes of birth when compared with non-instrumental vaginal delivery, followed by intrapartum cesarean section, vacuum delivery and pre-labor cesarean section (Table 2). Across both vaginal and cesarean births women with bleeding/platelet disorders or placenta previa were at increased risk of transfusion. Amongst vaginal births, forceps deliveries and multiple births were also associated with a more than doubling of the risk of transfusion, while amongst cesarean deliveries preterm births of <33 weeks gestation and antepartum hemorrhage were associated with a more than doubling of risk. Nulliparous women were at greater risk of transfusion when delivering vaginally, as were women with a previous cesarean (Table 2).

When included in the model, iron deficiency anemia was associated with an increased risk of transfusion (vaginal RR 7.1 (6.4,7.9); cesarean RR 4.5(3.9,5.6)), leaving other estimates largely unchanged. However, identification of women with iron deficiency anemia has low sensitivity (5.7-12.0%)(19) and so this was excluded from the final model.

Discussion

Transfusion of blood or blood products occurred in 1 in every 71 pregnancies in NSW between 2001 and 2010, with the majority of these related to hemorrhage. The majority of transfusions occurred during the birth admission, which is unsurprising given the large

proportion associated with PPH, which typically occur within 24 hours after birth. The small proportion of antenatal transfusions (4.0%) is similar to the findings of several single hospital audit studies which found 4-7%(20-22) of transfusions in obstetrics occur antenatally. Few women needed transfusion during more than one admission, or in more than one pregnancy. Although there are many documented risk factors for transfusion in the obstetrics population, the transfusion rate among women with no prior indication for blood transfusion was 1.0%, indicating that transfusion in otherwise healthy women is not uncommon.

Over the last 10 years there has been an increase in the use of blood and blood products throughout pregnancy, from one woman in every 85 pregnancies in 2001 to one woman in every 61 pregnancies in 2010. Obstetric patients use a small proportion of the blood supply overall (3-4%),(23) however, there is potentially increasing demand in this sub-population at a time when resources are becoming more limited.(1) One possible explanation for the increase is the changing maternal population, with more older mothers, women with previous cesarean sections, and having more comorbid conditions,(6, 11) however we found that the trend persisted when changes in these factors were taken into account. This is similar to the finding of Kuklina et al. who used the United States National Inpatient Sample to examine changes in maternal morbidity between 1998-2005, and found an increasing trend in transfusion persisted, despite adjustment for confounders.(7) This may reflect a change in clinician behavior in treating higher risk women.

Another possible reason for the increase in transfusion is the recent increase in PPH, which has been observed both in NSW(24) and overseas.(6, 8, 11, 12) As the majority of transfusions are performed in admissions with a diagnosis of hemorrhage, an increase in PPH would likely lead to an increase in blood transfusions, as has been observed elsewhere.(8, 9) Similar to transfusion generally, this increase in PPH is not able to be fully accounted for by the change in maternal characteristics.(12, 24) The increase in transfusion is also possibly

linked to increased severity of PPH. In both Ireland and Canada there have been reports of increasing severity of PPH.(9, 11)

The increase in transfusion rates may also reflect a change in practice, with clinicians using less restrictive criteria for transfusion than in the past, rather than reflecting an increase in severity of bleeding. We were unable to assess changes in transfusion thresholds, however there has been growing awareness of risks associated with transfusion, and concerns over the future availability and cost of blood.(1, 2) Against this background, it would be expected that changing practice should reduce rather than increase transfusion rates. Interestingly, the slight dip in transfusion rates in 2008 coincided with a statewide initiative to decrease obstetric transfusions,(25) however this decline was not maintained.

Similar to other studies, we found increased risk of transfusion associated with bleeding and platelet disorders,(26) placenta previa,(15, 27) antepartum hemorrhage,(10, 15) multiple births,(28) primparous women,(10, 27, 28) large birthweight,(10, 28) and maternal hypertension.(10, 15) Vaginal birth after cesarean carried a higher risk of transfusion than repeat cesarean.(10, 15, 28) Preterm birth was also associated with higher rates of transfusion, which has been demonstrated elsewhere,(27) and is possibly related to anemia which is a risk factor for preterm birth and transfusion.(29) It should be noted that while bleeding and platelet disorders were associated with seven to nine times the risk of transfusion, the overall population burden of this group is small, due to the rarity of these conditions.

We found both instrumental and cesarean delivery were associated with an increased risk of transfusion. There were higher transfusion rates following forceps deliveries than vacuum deliveries, and higher rates following intrapartum than pre-labor cesarean sections. Cesarean section had higher risk of transfusion than non-instrumental vaginal delivery, as has been reported elsewhere,(10, 15, 27) with this risk increased if the cesarean section was performed after the onset of labor. A Danish study, however, found that planned cesarean section had a

lower risk of transfusion than a planned vaginal birth, although the 'planned vaginal birth' group included women who had instrumental births and intrapartum cesarean sections.(28)

We found the rate of transfusion to be much lower in private hospitals compared with public, which is consistent with lower risk women giving birth in appropriate settings. (30-32) In Australia, tertiary obstetric care is only available in public hospitals. Tertiary hospitals had the highest rates of transfusion of platelets and coagulation factors, which may reflect increased complexity of cases in these hospitals. Alternatively higher blood product use in tertiary settings could reflect better access to products in the larger centers. Blood product use was more common with older mothers, private patients (particularly those in public hospitals), multiparous women and those having a cesarean birth. Without information on severity of bleeding it is difficult to know the significance of these findings. Platelets and coagulation factors are usually transfused in cases of severe bleeding in order to replace lost clotting factors,(33) and are typically included as part of a massive transfusion protocol.(34) The increased use of blood products observed may reflect increased severity of hemorrhage amongst these women.

This study reflects the population burden of blood and blood product use in obstetrics in Australia. The use of longitudinally linked data means allowed for the examination of blood product use within pregnancy, and over subsequent pregnancies. Validated and reliably collected information was available in either dataset. The large number of women in the sample allowed for adjustment by a range of risk factors. Use of administrative datasets however has limitations. It lacks clinical detail, such as quantity of blood transfused, indication for transfusion and hemoglobin measurements. While this information would provide insight into the severity of cases requiring transfusion, the available data are sufficient to highlight risk factors and numbers of women exposed to transfusion. Anemia is not well reported in the hospital data, capturing only the most severe cases when such a diagnosis would have affected the hospital stay.(18) This would cause an overestimation of

the transfusion risk associated with anemia, however results seen here are consistent with those reported elsewhere for severe anemia.

Obstetric transfusion represents a small proportion of overall blood use, however use of blood in obstetrics is rising and there is potential for this to continue as PPH rates continue to increase. Principles of patient blood management such as the prompt recognition of underlying coagulopathies, understanding of the pathophysiology, and the use of point of care testing and measurement of fibrinogen levels in the setting of acute hemorrhage will be important in reducing transfusion rates. As it has not been possible in this study to determine the exact indications and "triggers" for red cell transfusions it is difficult to opine as to the appropriateness of many of the transfusions, especially in the non bleeding group. Clearly, in exsanguinating hemorrhage transfusion is essential and a life-saving measure with questions revolving more around hemodynamic and coagulopathic parameters. On the other hand, in hemodynamically stable patients in whom hemorrhage has been controlled or is not the problem, the issues of patient blood management and transfusion are different. Tolerance of anemia in young healthy women without comorbities is important. The implementation of therapy, such as IV or oral iron will expedite hemopoietic recovery. Some reduction in transfusion rates may be possible through increased awareness surrounding the differing transfusion risk associated with mode of delivery, and through targeting treatment of anemia during pregnancy. Additional reduction in blood use may be achievable through exploring variation in blood use between hospitals.

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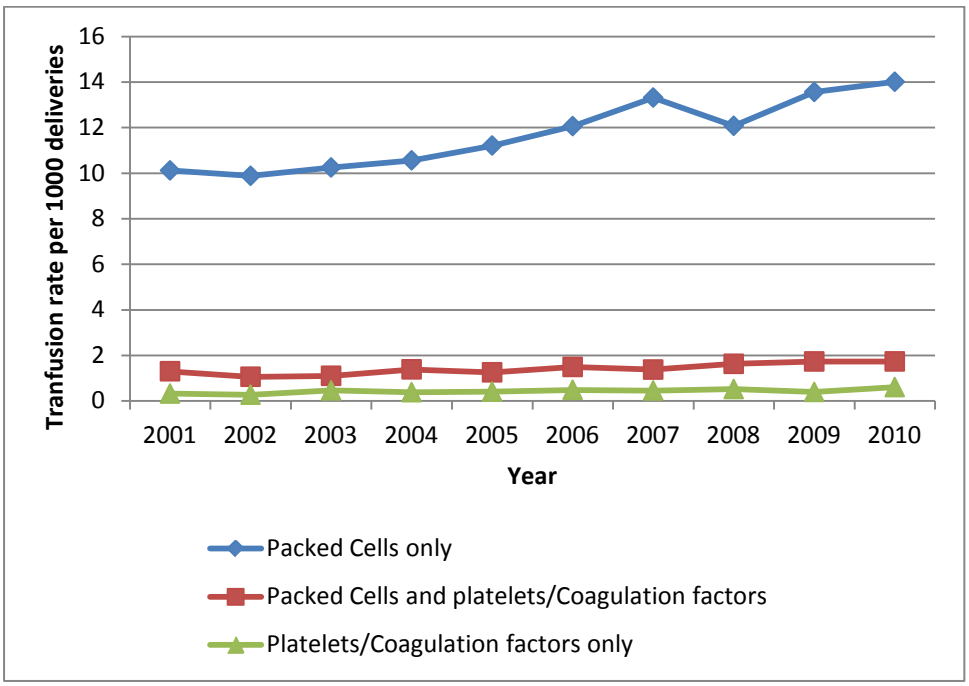
Figure Legends

Figure 1 Rate of transfusions per 100,000 births, NSW 2001-2010*



*this includes any transfusion during the antenatal period, birth admission and postnatally.

Supplemental Digital Content

Appendix 1: ICD10 AM and procedure codes for selected conditions and procedures

Table 1 Characteristics of pregnancies by blood product transfusion status during pregnancy, NSW 2001-2010.

	Variable	**Packed red cells/blood**	**Platelet/ Coagulation Factors**	**Any Blood products**	**No Blood products**	**Rate per 100,000 births**
Total	Pregnancies	11760 (100.0)	1648 (100.0)	12147 (100.0)	879767 (100.0)	1362
Maternal age	<20 years	612 (5.2)	42 (2.5)	626 (5.2)	33500 (3.8)	1834
	20-34	8392 (71.4)	1084 (65.8)	8682 (71.5)	658286 (74.8)	1302
	35+	2756 (23.4)	522 (31.7)	2839 (23.4)	187981 (21.4)	1488
Private patient	Yes	2602 (22.1)	472 (28.6)	2724 (22.4)	296410 (33.7)	911
	No	9158 (77.9)	1176 (71.4)	9423 (77.6)	583357 (66.3)	1590
Smoker	Yes	1963 (16.7)	197 (12.0)	2002 (16.5)	121511 (13.8)	1621
	No	9767 (83.1)	1442 (87.5)	10113 (83.3)	756086 (85.9)	1320
Multiple birth	Yes	612 (5.2)	92 (5.6)	631 (5.2)	13383 (1.5)	4503
	No	11148 (94.8)	1556 (94.4)	11516 (94.8)	866384 (98.5)	1312
Nullipara	Yes	5608 (47.7)	738 (44.8)	5812 (47.8)	369525 (42.0)	1548
	No	6136 (52.2)	907 (55.0)	6317 (52.0)	509032 (57.9)	1226
Previous Cesarean	Yes	1726 (14.7)	361 (21.9)	1792 (14.8)	119573 (13.6)	1477
	No	10034 (85.3)	1287 (78.1)	10355 (85.2)	760194 (86.4)	1344

Bleeding/platelet	Yes	1132 (9.6)	291 (17.7)	1275 (10.5)	7713 (0.9)	14186
Disorders	No	10628 (90.4)	1357 (82.3)	10872 (89.5)	872054 (99.1)	1231
Antepartum	Yes	1045 (8.9)	238 (14.4)	1084 (8.9)	22179 (2.5)	4660
Hemorrhage	No	10715 (91.1)	1410 (85.6)	11063 (91.1)	857588 (97.5)	1274
Placenta Previa	Yes	962 (8.2)	228 (13.8)	979 (8.1)	8485 (1.0)	10344
	No	10798 (91.8)	1420 (86.2)	11168 (91.9)	871282 (99.0)	1266
Iron deficiency	Yes	772 (6.6)	56 (3.4)	778 (6.4)	4725 (0.5)	14138
Anemia	No	10988 (93.4)	1592 (96.6)	11369 (93.6)	875042 (99.5)	1283
Gestational age (at	20-32	736 (6.3)	207 (12.6)	791 (6.5)	13436 (1.5)	5560
birth)	33-36	1182 (10.1)	283 (17.2)	1266 (10.4)	42836 (4.9)	2871
	37+	9842 (83.7)	1158 (70.3)	10090 (83.1)	823495 (93.6)	1210
Delivery type	Normal vaginal	5226 (44.4)	491 (29.8)	5341 (44.0)	537476 (61.1)	984
	Cesarean	4343 (36.9)	947 (57.5)	4588 (37.8)	246130 (28.0)	1830
	Pre-labor CS	2319 (19.7)	583 (35.4)	2484 (20.4)	141349 (16.1)	1727
	Intrapartum CS	2023 (17.2)	364 (22.1)	2103 (17.3)	104779 (11.9)	1968
	Instrumental	2176 (18.5)	206 (12.5)	2202 (18.1)	96308 (10.9)	2235

	Forceps	1068 (9.1)	102 (6.2)	1081 (8.9)	32663 (3.7)	3204
	Vacuum	1108 (9.4)	104 (6.3)	1121 (9.2)	63645 (7.2)	1731
Induction	Yes	3794 (32.3)	540 (32.8)	3910 (32.2)	236932 (26.9)	1623
	No	7966 (67.7)	1108 (67.2)	8237 (67.8)	642835 (73.1)	1265
Birthweight (for	Small	895 (7.6)	165 (10.0)	959 (7.9)	83218 (9.5)	1139
gestation)	Average	9039 (76.9)	1294 (78.5)	9333 (76.8)	703661 (80.0)	1309
	LGA	1826 (15.5)	189 (11.5)	1855 (15.3)	92888 (10.6)	1958
Hospital of birth	Tertiary	5934 (50.5)	982 (59.6)	6157 (50.7)	358695 (40.8)	1688
	Regional	2844 (24.2)	210 (12.7)	2906 (23.9)	188394 (21.4)	1519
	Urban/other	1488 (12.7)	182 (11.0)	1522 (12.5)	119278 (13.6)	1260
	Private	1494 (12.7)	274 (16.6)	1562 (12.9)	213400 (24.3)	727

Denominator=Pregnancies

Table 2 Factors associated with blood or blood product transfusion in the birth admission, NSW 2001-2010.

		Vaginal deliveries				Cesarean Deliveries			
		Univariate model		Multivariable model		Univariate model		Multivariable model	
		RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Maternal age	Under 20	1.4	(1.27,1.55)	1.2	(1.05,1.29)	1.8	(1.51,2.08)	1.5	(1.27,1.75)
	20-35	1.0		1.0		1.0		1.0	
	35+	1	(0.97,1.09)	1.1	(1.02,1.16)	1.2	(1.09,1.24)	1.2	(1.09,1.25)
	Private Patient	0.6	(0.56,0.63)	0.8	(0.70,0.84)	0.5	(0.44,0.50)	0.8	(0.69,0.84)
	Smoker	1.1	(1.02,1.17)	1.1	(1.07,1.22)	1.5	(1.40,1.65)	1.1	(1.00,1.18)
	Australian born	0.8	(0.78,0.86)	0.8	(0.76,0.85)	0.9	(0.80,0.91)	0.9	(0.81,0.93)
	Multiple birth	4.3	(3.78,4.86)	2.8	(2.47,3.26)	2.5	(2.23,2.75)	1.7	(1.50,1.91)
	Nullipara	1.7	(1.59,1.74)	1.4	(1.35,1.51)	0.8	(0.78,0.88)	0.7	(0.62,0.72)
	Previous Cesarean	1.5	(1.37,1.69)	1.8	(1.63,2.02)	0.7	(0.62,0.71)	0.7	(0.68,0.80)
	Bleeding/platelet disorder	9.6	(8.77,10.4)	7.8	(7.11,8.48)	11.4	(10.51,12.35)	8.7	(7.93,9.50)
	Iron deficiency anemia	9.1	(8.22,10.07)			9.4	(8.35,10.52)		
	Chronic Hypertension	1.6	(1.31,2.05)			1.5	(1.25,1.86)		
	Pregnancy hypertension	2	(1.88,2.15)	1.6	(1.48,1.70)	1.7	(1.56,1.80)	1.5	(1.41,1.65)

	Any Diabetes	1.2	(1.11,1.35)			1.1	(0.96,1.18)		
	Placenta Previa	7.3	(5.91,8.95)	4.6	(3.70,5.83)	7.3	(6.78,7.81)	5.7	(5.24,6.22)
	Antepartum Hemorrhage	2.6	(2.34,2.87)	1.9	(1.68,2.09)	4.6	(4.25,4.99)	2.2	(2.02,2.43)
	Augmentation of labor	1.5	(1.39,1.59)	1.3	(1.20,1.39)	0.9	(0.83,1.07)		
	Induction	1.5	(1.47,1.61)	1.5	(1.38,1.53)	1.1	(0.98,1.14)	1.1	(1.04,1.25)
	Intrapartum CS					1.1	(1.08,1.21)	1.3	(1.24,1.43)
	Prolonged labor	2.2	(2.03,2.37)			1.6	(1.37,1.89)		
	Regional analgesia	1.5	(1.40,1.55)						
Birthweight	Small	0.8	(0.72,0.87)	0.7	(0.67,0.80)	0.9	(0.84,1.05)	0.8	(0.73,0.90)
(for	Average	1.0		1.0		1.0		1.0	
gestation)	Large	1.6	(1.52,1.74)	1.7	(1.60,1.84)	1.2	(1.14,1.33)	1.3	(1.19,1.39)
Gestational	Under 33 weeks	3	(2.66,3.39)	1.8	(1.56,2.11)	6.1	(5.55,6.67)	2.7	(2.43,3.02)
Age	33-36 weeks	1.5	(1.38,1.68)	1.2	(1.06,1.30)	3.1	(2.88,3.37)	1.7	(1.57,1.87)
	37+ weeks	1.0		1.0		1.0		1.0	
Delivery	Vaginal	1.0		1.0					
type	Forceps	3.5	(3.26,3.72)	2.8	(2.57,2.97)				

	Vacuum	1.9	(1.74,1.98)	1.6	(1.54,1.77)				
	Year of birth	1.1	(1.04,1.06)	1	(1.04,1.06)	1	(1.01,1.03)	1	(1.02,1.05)
Hospital type	Tertiary	1.3	(1.19,1.37)	1.1	(1.00,1.15)	1.4	(1.27,1.56)	1.1	(0.96,1.18)
	Metropolitan	1.0		1.0		1.0		1.0	
	Regional	1.2	(1.09,1.28)	1.2	(1.14,1.34)	1.2	(1.09,1.37)	1.3	(1.12,1.42)
	Private hospitals	0.6	(0.54,0.65)	0.6	(0.55,0.70)	0.5	(0.41,0.52)	0.6	(0.56,0.75)

Reference categories are absence of risk factor unless otherwise specified