Title page

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Risk factors for severe postpartum haemorrhage: a population-based retrospective cohort study

Short running title

Risk factors for severe postpartum haemorrhage

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Conflict of interest

All authors declare they have no conflict of interest

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ABSTRACT

Background

Severe postpartum haemorrhage (PPH) is a serious clinical problem that is increasing in incidence.

Aim

To identify risk factors for severe PPH.

Materials and Methods

Population-based retrospective cohort study of all women who gave birth in Victoria in 2009-2013 using the validated Victorian Perinatal Data Collection. Three multivariable logistic regression models estimated the adjusted risk of severe PPH. Adjusted Odds Ratios (aOR) and their 95% confidence intervals are reported.

The primary outcome was severe PPH (estimated blood loss of ≥ 1500 mL).

Results

Severe PPH occurred in 1.4% of all births (n=5122). Maternal characteristics significantly associated with severe PPH included: multiple pregnancy; older maternal age; overweight/obesity; first births. Other risk factors included placental complications, macrosomia, instrumental vaginal birth, 3rd and 4th degree perineal laceration, in-labour caesarean section, birth at a gestation other than 37-41 weeks', duration of labour 12-<24 hours, and use of oxytocin infusions in labour. Planned pre-labour caesarean section was associated with reduced odds of severe PPH.

Severe PPH also occurred in 0.7% (n=104) of women with none of the identified risk factors.

Conclusions

Numerous risk factors for severe PPH are identified but some cases are not modifiable or predictable. Limiting use of oxytocin infusions in labour to cases with clear indications, and strategies to prevent severe perineal lacerations would prevent some severe PPHs. Close surveillance of all women in the hours immediately following birth is crucial to detect and manage excessive blood loss and reduce severe PPH and associated morbidity.

INTRODUCTION

Primary postpartum haemorrhage (PPH) is an obstetric emergency that continues to be a leading cause of maternal death in developed and developing countries alike.¹ For every death there are numerous PPHs that cause substantial morbidity.²

Primary PPH is defined as blood loss of 500 mL or more in the 24 hours following birth.³ Most women giving birth are young and healthy and can compensate for a small to moderate PPH^{3,4} and recover fully. However more severe PPH is associated with substantial morbidity and surgical and medical intervention including transfusion, peripartum hysterectomy, and admission to intensive care units.⁵ Severe PPH is defined variously in the literature as ≥ 1000 mL,⁶ ≥ 1500 mL,⁷⁻⁹ and >2000 mL.¹⁰ Some definitions additionally include other factors such as peripartum hysterectomy¹¹ or blood transfusion.¹¹

The characteristics of women giving birth are changing (parity, age, obesity), as is the approach to managing labour and birth (e.g. expectations of progress during labour, management of post-term pregnancy, more induction and augmentation of labour and higher caesarean section (CS) rates).⁸ It is important to understand which, if any, of these factors increase the risk of severe PPH in order to anticipate and prepare for it, and to modify those risk factors that are amenable to change.

Since Haynes' comprehensive review of PPH in Victoria, Australia in 2004,¹² the incidence of PPH and severe PPH have risen considerably. Changes in 2009 to the PPH-related details included in the Victorian Perinatal Data Collection (VPDC) now enable analysis of the severity of PPH. This study aimed to investigate the maternal characteristics, characteristics of the pregnancy and birth, and the management of labour and birth which were associated with an increased risk of severe primary PPH for women giving birth in Victoria, Australia in 2009–2013.

MATERIALS AND METHODS

Design

Population-based retrospective cohort study.

Study population and data source

All women who gave birth in Victoria from 1 January 2009 to 31 December 2013.

De-identified data were obtained from the VPDC, a validated, statutory, prospectively-collected perinatal dataset that includes all births occurring at public and private hospitals and homebirths in Victoria. It comprises demographic and clinical information and is submitted at

the completion of the birth admission, usually by midwives, for all births of ≥ 20 weeks (or with a birthweight of ≥ 400 g if gestation is unknown). Women who had twins or higher-order births were included once only in the de-identified dataset and terminations of pregnancy were excluded. The accuracy of items collected by VPDC on births in 2011 has been validated.^{13, 14}

Outcome definition

The estimated volume of blood lost in the 24 hours following birth is reported for all births. This was dichotomised into <1500 mL or ≥ 1500 mL to meet our definition of severe PPH. By definition, each woman in the dataset was followed up for this outcome for 24 hours.

Statistical analysis

Maternal characteristics, selected pregnancy-related factors, aspects of management of labour and birth, and details of the birth were cross-tabulated with severe PPH. Percentages are reported and statistical significance was assessed by Chi-square tests.

Univariate logistic regression was performed to measure the association between these variables and severe PPH. Odds ratios and their 95% confidence intervals are reported. Reference groups were chosen as representing the most 'normative' group. Since severe PPH is a rare outcome ($<10\%$ of cases), the Odds Ratio obtained from the logistic regression approximates the Relative Risk.

Adjusted models

Three multivariable logistic regression models were developed. In each case, variables were selected a priori based on the literature and availability in the de-identified dataset made available for this study. Such variables significantly associated with severe PPH at a univariate level of $p < 0.05$ were entered into the model. Manual backwards elimination was carried out using likelihood ratio tests to determine the effect of deleting the variable from the model. Variables were deleted when the p-value for the likelihood ratio test was >0.05 and deleting them resulted in $<10\%$ change in the adjusted Odds ratio.

The first model reports on characteristics of the women associated with severe PPH; the second adds characteristics and complications of the pregnancy and birth; the third focuses

only on women who experienced labour and includes maternal characteristics, complications of pregnancy and aspects of the management of labour.

Treatment of variables included in the models are described in Box 1.

Missing data

Estimated blood loss was not reported for 5897 women (1.6%). These were excluded from all analyses. Fewer than 1% of cases had missing data for any variable other than socio-economic quintile (40,977 women (11.1%) related to incomplete address details), number of previous CS (5823 women, 1.6%), Body Mass Index (BMI) (44,840 women, 12.1%) and duration of labour (4752 women who experienced labour, 1.6%). Missing values for these four variables were included in the multivariable models as a 'not reported' category. Those with missing values for parity, plurality, maternal age or maternal country of birth were excluded from the multivariable models (3661 women, 1.0%). The 69,508 women who did not experience labour and the 300 women for whom this was not reported were excluded from the 'labour' model.

Analyses were carried out using Stata 15 (StataCorp, College Station, Tx, USA).

Approvals

The project was approved by La Trobe University Human Research Ethics Committee (FHEC 12/025). The Victorian Consultative Council on Obstetric and Paediatric Mortality and Morbidity (CCOPMM) approved the use of de-identified VPDC data for this project.

RESULTS

Over the study period, 364,706 women gave birth and had estimated blood loss reported, of whom 5122 experienced a severe PPH (1.4%).

Characteristics of women included in the study are described in Table 1.

*INSERT TABLE 1 AROUND HERE

Maternal characteristics model (Model 1)

Women having their first baby were more likely to experience a severe PPH than those having a subsequent baby; as were women aged 35 years or older more likely than those aged 20-34 years, and overweight and obese women more likely than normal-weight women to experience a severe PPH. Women born in North-East Asia, South-East Asia, Oceania and Antarctica were more likely than those born in Australia, while women born in Southern and

Central Asia were less likely, to have a severe PPH (all $P < 0.001$) (Table 2). Women with a multiple pregnancy were also more likely to experience a severe PPH.

After adjusting for all other maternal characteristics included in the model, women with a multiple pregnancy had 2.8-fold elevated odds of severe PPH (aOR 2.81, 95%CI 2.5, 3.2). Those having a first birth (aOR 1.31, 95%CI 1.2, 1.4), older women (aOR 1.15, 95%CI 1.1, 1.2), overweight (aOR 1.18, 95%CI 1.1, 1.3) and obese (aOR 1.40, 95%CI 1.3, 1.5) women and those born in North-East Asia (aOR 1.57, 95%CI 1.4, 1.8), South-East Asia (aOR 1.51, 95%CI 1.4, 1.7) and Oceania (excluding Australia) (aOR 1.57, 95%CI 1.4, 1.8) had increased odds of severe PPH, while women born in South or Central Asia (aOR 0.80, 95%CI 0.7, 0.9) and socio-economically advantaged women (aOR 0.86, 95%CI 0.8, 0.9) had reduced odds of severe PPH (Table 2).

*INSERT TABLE 2 AROUND HERE

Birth model (Model 2)

After adjustment for all variables included in the birth model, the relationships of the maternal characteristics to severe PPH were largely unchanged from those in Model 1 (Table 3).

Placenta accreta, placenta praevia and placental abruption were each associated with a large increase in odds of severe PPH. Third or fourth degree perineal laceration, forceps birth, vacuum birth, CS after the onset of labour, fetal death in utero/stillbirth, macrosomia, pre-term and post-term birth, and use of an oxytocin infusion in labour were all associated with increased odds of severe PPH. Women who had a CS before the onset of labour were at reduced odds of severe PPH relative to those who had an unassisted vaginal birth (Table 3).

*INSERT TABLE 3 AROUND HERE

Labour model (Model 3)

Results of Model 3 are presented in Table 4. The relationships between maternal characteristics, complications of pregnancy and severe PPH were similar to models 1 and 2, with the exception of maternal age, preterm birth after 27 weeks, and maternal birth in South or Central Asia not being associated with severe PPH.

Of the women who experienced labour, those who received an oxytocin infusion in labour, whether to induce or augment, had a 20% increase in odds of severe PPH (Table 4). Duration of labour of 12 to <24 hours was associated with a 12% increase in odds of severe PPH

compared with a labour duration of 4 to <12 hours. In contrast, very short labour was not associated with an increase in severe PPH, and those lasting 2 to <4 hours were associated with a 15% reduction in odds of severe PPH.

*INSERT TABLE 4 AROUND HERE

Following identification of the above risk factors, a post hoc 'low risk' variable was created, representing a woman who had none of the characteristics that were associated with increased risk of severe PPH – she was multiparous with no previous CS, aged 20-34 years, with a BMI of 18.5 to <25 kg/m², was born in Australia, did not have placental complications, had a labour that lasted <12 hours without having an oxytocin infusion to induce or augment labour, and gave birth normally to a singleton, liveborn, non-macrosomic baby at term. This exclusive group included only 14,999 (4.1%) women, of whom 104 had a severe PPH (0.7%) compared with 5018 (1.4%) of the remaining women (P<0.001).

DISCUSSION

Risk factors for any PPH have been studied extensively, with many consistent findings, e.g., primiparity¹⁵ prior CS,¹⁶ use of induction agents,¹⁵ prior PPH,^{9, 15, 17-19} multiple pregnancy,^{15, 20} and advanced maternal age²⁰. However, there has been less examination of risk factors for severe PPH, a more clinically relevant problem. Severe PPH occurred in 1.4% of all births in this large study. Several maternal characteristics were associated with severe PPH: multiple pregnancy, maternal country of birth, older maternal age, obesity, primiparity and prior CS. We also identified placental complications, macrosomia, stillbirth/fetal death-in-utero, use of oxytocin infusions in labour, labour lasting ≥12 hours, instrumental vaginal birth or CS during labour and severe perineal lacerations as risk factors for severe PPH, while women who had a CS before the onset of labour were at reduced odds of severe PPH.

The incidence of severe PPH in this study is consistent with the range reported in the literature when the same or very similar definitions were used.^{7, 9, 21}

Our finding that the use of an oxytocin infusion in labour increased the risk of severe PPH is consistent with the findings of Nyflot et al,⁹ as well as being consistent with the association found between induction of labour more generally and severe PPH by a number of authors.²¹⁻

²³ This effect remained significant after adjustment for important confounders including nulliparity and duration of labour. The hypothesized mechanism is the desensitisation of

uterine oxytocin receptors following oxytocin infusions, thus limiting the efficiency of uterine contraction after the birth.²⁴⁻²⁶

The increase in the odds of a severe PPH found in this study for older women was smaller than that reported by others using a similar definition of severe PPH^{23, 27} as was the risk with overweight and obesity.²² Age was accurately reported in the dataset, but the large amount of missing data for BMI may have diluted its association with severe PPH.

Ethnicity per se was not available in this dataset, but our finding of an increased risk of severe PPH for women born outside the host country has been reported by others.^{15, 21, 22, 28}

Many of the risk factors identified in this study are consistent with the existing literature: multiple pregnancy,^{9, 23, 27} macrosomia,^{9, 22, 23} primiparity.^{9, 23} The increased risk seen with placental complications is similar to the findings of Kramer et al,²⁷ though we found a greater increase in risk for women with placenta praevia than Fyfe et al.²²

We found a larger increase in risk for vaginal births assisted with forceps than for vacuum extraction, consistent with the findings of Fyfe et al.²² Other authors have combined these into a single operative vaginal birth category and report a risk intermediate between our vacuum and forceps aORs.^{9, 27} Our finding of an increased risk of severe PPH with CS conducted after the onset of labour, but a reduction in risk for CS conducted before labour, has not been reported by others, though a smaller increase in risk for those carried out before labour than in labour has been reported previously.^{8, 22}

Importantly, though women with identified risk factors were more likely to experience a severe PPH, 0.7% of women who had none of the identified risk factors also experienced a severe PPH. This is an important finding as it equates to 2% of all cases of severe PPH.

Strengths and limitations

This paper benefits from the inclusion of all women who gave birth in Victoria, thus eliminating the sampling or response bias that is possible in single sites or in surveys respectively. The large sample size means that these analyses were adequately powered. Missing data were minimal, with the exception of two co-variables: BMI and number of prior CS. The accuracy of the data used in these analyses was measured for 2011 – the mid-point of the study period and, for items overall, was high (90–100%) with the exception of BMI and labour duration.¹⁴ The accuracy of reporting of EBL ≥ 1500 mL was 99.7% however, the sensitivity was lower (71.4%), indicating a degree of under-reporting, sometimes related to not reporting the blood loss for the entire 24 hours. Specificity of 100% indicates there were no falsely reported cases of severe PPH.¹³

Limitations include the inherent inaccuracy of estimation of blood loss by clinicians. Some potentially informative co-variables were not available e.g. pre-eclampsia, previous PPH, episiotomy, chorioamnionitis and whether artificial reproductive technology was used. The cause of the PPH (i.e. atony or trauma) is not yet reported to VPDC.

The use of oxytocin infusions to induce or augment labour is one of the few risk factors found that is amenable to change after clinical presentation. Further research that considered the existence of a dose-response would be informative, but limiting the use of oxytocin infusions in labour to cases in which they are clearly indicated would likely reduce the number of severe PPHs. Strategies to decrease the incidence of 3rd and 4th degree perineal lacerations would be expected to also result in fewer PPHs.

The risk factors identified here can be used to plan the appropriate place of birth for some women e.g., those with placental complications. Improved pre-pregnancy care could also potentially make a difference e.g., regarding obesity.

Our finding that 0.7% of women with none of the risk factors we identified, compared with 1.4% of all women giving birth, experienced severe PPH serves as a reminder that severe PPH is not entirely predictable and can occur following any birth. Consistent with the American Consensus Bundle on Obstetric Hemorrhage,²⁹ identification of women at risk of severe PPH and careful postpartum surveillance for all women will promote the early detection and prompt management of PPH and limit adverse outcomes. Clinicians at all levels of maternity service need training and resources to be skilled, prepared and equipped to recognise and manage severe PPH.

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Table 1: Characteristics of the population - women who gave birth in Victoria in 2009-2013

	n	%
Maternal characteristics		
Maternal country of birth		
Australia	251,365	67.8
Americas	4,748	1.3
North Africa and Middle East	11,488	3.1
North East Asia	13,572	3.7
North Western Europe	11,358	3.1
Oceania and Antarctica	10,259	2.8
South East Asia	22,073	6.0
Southern and Central Asia	27,890	7.5
Southern and Eastern Europe	7,334	2.0
Sub-Saharan Africa	7,334	2.0
Not reported	3,182	0.9
Parity		
First birth	163,651	44.2
Second birth	127,800	34.5
Third birth		14.0

	51,742	
Fourth or subsequent birth	27,401	7.4
Not reported	9	0
Maternal age (years)		
Younger than 20 years	8,768	2.4
20 to 34	266,850	72.0
35 to 44	93,848	25.3
45 or older	878	0.2
Not reported	259	0.1
Socio-economic quintile		
1. Most deprived	66,375	17.9
2	66,019	17.8
3	65,710	17.7
4	65,454	17.7
5. Least deprived	66,048	17.8
Not available	40,977	11.1
Number of previous CS		
0	147,694	39.9
1		12.4

	46,088	
2	10,701	2.9
3	2,010	0.5
4	406	0.1
No prior birth	157,881	42.6
Not reported	5,823	1.6
Body Mass Index		
<18.5	9,707	2.6
18.5 to <25	163,875	44.2
25 to <30	87,345	23.6
≥30	64,836	17.5
Not reported	44,840	12.1
Multiple pregnancy	5,979	1.6
Pregnancy and birth factors		
Placental abruption	653	0.2
Placenta praevia (with or without haemorrhage)	2,402	0.7
Other antepartum haemorrhage	7,638	2.1
Obstructed labour	2,476	0.7

Intrapartum care lead

Midwife	104,394	28.2
Obstetrician	238,324	64.3
GP	25,510	6.9
Other/inadequately described	2,375	0.6
Onset of labour		
Spontaneous	207,955	56.1
Induced	92,840	25.1
No labour (CS)	69,508	18.8
Inadequately described	300	0.1
Gestation		
20-27 weeks	2,135	0.6
28-31 weeks	2,466	0.7
32-36 weeks	21,783	5.9
37-41 weeks	339,821	91.7
42+ weeks	4,373	1.2
Not reported	25	0.0
Method of birth		
Unassisted vaginal		53.4

	197,961	
Forceps	23,264	6.3
Vacuum	30,179	8.1
Unplanned caesarean (pre-labour)	3,455	0.9
Planned caesarean (pre-labour)	59,347	16.0
Unplanned caesarean (in labour)	43,883	11.8
Planned caesarean (in labour)	12,332	3.3
Not reported	182	0.05
Stillborn baby	1,833	0.5
Macrosomia (≥ 4000 g)	44,338	12.0
Placenta accreta	69	0.0
3rd or 4th degree perineal laceration	7,071	1.9
Prophylactic oxytocic in 3rd stage	362,859	97.9
Labour-related (excludes women who did not experience labour)		
Oxytocin infusion in labour	99,594	33.1
Duration of labour		
< 2 hours	25,027	8.3
2 to <4 hours	61,717	20.5

4 to <12 hours	161,214	53.6
12 to <24 hours	44,648	14.8
≥24 hours	3,437	1.1
Not reported	4,752	1.6

Table 2: Maternal characteristics associated with severe postpartum haemorrhage (PPH), all women who gave birth in Victoria, 2009-13†

Potential risk factor	Women with severe PPH		p	OR‡	CI	AOR§	CI
	n	%					
Maternal characteristics							
Maternal country of birth			<0.001				
Australia	3343	1.35		1.00	reference	1.00	reference
Americas	61	1.31		0.96	[0.8, 1.2]	0.97	[0.7, 1.2]
North Africa and Middle East					[0.7,		
East	136	1.19		0.88	1.04]	0.88	[0.7, 1.0]
North East Asia	266	1.99		1.48	[1.3, 1.7]	1.57	[1.4, 1.8]
					[0.7,		
North Western Europe	131	1.17		0.86	1.03]	0.88	[0.7, 1.1]
Oceania and Antarctica	223	2.20		1.64	[1.4, 1.9]	1.57	[1.4, 1.8]
South East Asia	422	1.93		1.44	[1.3, 1.6]	1.51	[1.4, 1.7]
Southern and Central Asia	301	1.09		0.80	[0.7, 0.9]	0.80	[0.7, 0.9]
Southern and Eastern Europe	108	1.50		1.11	[0.9, 1.3]	1.12	[0.9, 1.4]
Sub-Saharan Africa	84	1.16		0.85	[0.7, 1.1]	0.84	[0.7, 1.1]

Not reported	47	1.50				
Maternal age (years)			<0.001			
				[0.96,		
Younger than 20 years	135	1.55	1.14	1.4]	1.02	[0.9, 1.2]
20 to 34	3600	1.37	1.00	reference	1.00	reference
				[1.03,		
35 or older	1387	1.50	1.10	1.2]	1.15	[1.1, 1.2]
Socio-economic quintile			<0.001			
1. Most deprived	1014	1.55	1.04	[0.9, 1.1]	1.04	[1.0, 1.1]
2	888	1.36	0.91	[0.8, 1.0]	0.92	[0.8, 1.0]
3	964	1.49	1.00	reference	1.00	reference
				[0.8,		
4	886	1.38	0.92	1.01]	0.92	[0.8, 1.0]
5. Least deprived	812	1.26	0.84	[0.8, 0.9]	0.86	[0.8, 0.9]
				[0.8,		
Not available	558	1.38	0.93	1.03]	0.95	[0.9, 1.1]
Number of previous CS			0.001			
No prior birth	2527	1.63	1.27	[1.2, 1.3]	1.31	[1.2, 1.4]
0	1890	1.29	1.00	reference	1.00	reference
1	489	1.10	0.85	[0.8, 0.9]	0.83	[0.8, 0.9]
2 or more	168	1.33	1.03	[0.9, 1.2]	0.97	[0.8, 1.1]
Not reported	48	0.90	0.66	[0.5, 0.9]	0.72	[0.5, 1.0]
Body Mass Index			<0.001			
<18.5	106	1.10	0.88	[0.7, 1.1]	0.82	[0.7, 1.0]
18.5 to <25	2027	1.25	1.00	reference	1.00	reference
25 to <30	1211	1.41	1.12	[1.0, 1.2]	1.18	[1.1, 1.3]
≥30	1071	1.68	1.34	[1.2, 1.4]	1.40	[1.3, 1.5]
Not reported	707	1.62	1.29	[1.2, 1.4]	1.25	[1.1, 1.4]
Plurality			<0.001			
Singleton pregnancy	4901	1.37	1.00	reference	1.00	reference
Multiple pregnancy	221	3.83	2.88	[2.5, 3.3]	2.80	[2.5, 3.2]

†excludes women for whom estimated blood loss was not reported, those with missing data on age, parity, plurality or maternal country of birth, and terminations of pregnancy.

‡ Odds Ratio; § Adjusted Odds Ratio and 95% confidence intervals (CI)

Table 3: Pregnancy and birth factors, and maternal characteristics associated with severe PPH, all women who gave birth in Victoria, 2009-2013†

Potential risk factor	Women with severe PPH		p	OR		AOR	
	n	%		‡	CI	§	CI
Maternal characteristics							
Maternal country of birth			<0.001				
	334	1.3		1.0			
Australia	3	5		0	reference	1.00	reference
		1.3		0.9			
Americas	61	1		6	[0.8, 1.2]	1.01	[0.8, 1.3]
		1.1		0.8			
North Africa and Middle East	136	9		8	[0.7, 1.0]	0.90	[0.8, 1.1]
		1.9		1.4			
North East Asia	266	9		8	[1.3, 1.7]	1.62	[1.4, 1.8]
		1.1		0.8			
North Western Europe	131	7		6	[0.7, 1.0]	0.89	[0.7, 1.1]
				1.6			
Oceania and Antarctica	223	2.2		4	[1.4, 1.9]	1.59	[1.4, 1.8]
		1.9		1.4			
South East Asia	422	3		4	[1.3, 1.6]	1.57	[1.4, 1.8]
		1.0		0.8			
Southern and Central Asia	301	9		0	[0.7, 0.9]	0.79	[0.7, 0.9]
				1.1			
Southern and Eastern Europe	108	1.5		1	[0.9, 1.3]	1.17	[1.0, 1.4]
Sub-Saharan Africa	84	1.1		0.8	[0.7, 1.1]	0.85	[0.7, 1.1]

		6	5			
Not reported	47	1.5				
			<0.00			
Maternal age (years)		1				
		1.5	1.1			
Younger than 20 years	135	5	4	[0.96, 1.4]	1.13	[0.9, 1.4]
	360	1.3	1.0			
20 to 34	0	7	0	reference	1.00	reference
	136	1.4	1.0			[1.03,
35 or older	1	8	9	[1.02, 1.2]	1.11	1.2]
			<0.00			
Socio-economic quintile		1				
	101	1.5	1.0			
1. Most deprived	4	5	4	[0.9, 1.1]	1.03	[0.9, 1.1]
		1.3	0.9			
2	888	6	1	[0.8, 1.0]	0.91	[0.8, 1.0]
		1.4	1.0			
3	964	9	0	reference	1.00	reference
		1.3	0.9			
4	886	8	2	[0.8, 1.01]	0.93	[0.8, 1.0]
		1.2	0.8			[0.8,
5. Least deprived	812	6	4	[0.8, 0.9]	0.87	0.95]
		1.3	0.9			
Not available	558	8	3	[0.8, 1.03]	0.93	[0.8, 1.0]
Number of previous CS			0.001			
	252	1.6	1.2			
No prior birth	7	3	7	[1.2, 1.3]	1.08	[1.0, 1.2]
	189	1.2	1.0			
Prior birth/s, no prior CS	0	9	0	reference	1.00	reference
			0.8			
Prior birth/s, 1 prior CS	489	1.1	5	[0.8, 0.9]	0.93	[0.8, 1.0]
Prior birth/s, 2 or more prior		1.1	0.8			
CS	117	4	8	[0.7, 1.1]	1.34	[1.2, 1.5]

			0.6			
Not reported	48	0.9	6	[0.5, 0.9]	0.59	[0.4, 0.8]
			<0.00			
Body Mass Index			1			
			0.8			
<18.5	106	1.1	8	[0.7, 1.1]	0.86	[0.7, 1.0]
	202	1.2	1.0			
18.5 to <25	7	5	0	reference	1.00	reference
	121	1.4	1.1			
25 to <30	1	1	2	[1.1, 1.2]	1.14	[1.1, 1.2]
	107	1.6	1.3			
≥30	1	8	4	[1.3, 1.5]	1.34	[1.2, 1.5]
		1.6	1.2			
Not reported	707	2	9	[1.2, 1.4]	1.15	[1.0, 1.3]
			<0.00			
Plurality			1			
	490	1.3	1.0			
Singleton pregnancy	1	7	0	reference	1.00	reference
		3.8	2.8			
Multiple pregnancy	221	3	8	[2.5, 3.3]	2.83	[2.4, 3.3]
Pregnancy and birth factors						
			<0.00			
Placental abruption			1			
		14.	12.			[6.2,
Yes	94	8	4	[9.9, 15.4]	7.85	10.0]
	502	1.3	1.0			
No	8	8	0	reference	1.00	reference
Placenta praevia (with or without haemorrhage)			<0.00			
			1			
		12.	10.			[8.9,
Yes	297	5	6	[9.3, 12.0]	10.3	11.9]
No	482	1.3	1.0	reference	1.00	reference

	5	3	0			
				<0.00		
APH other			1			
				2.6		
Yes	264	3.5	2	[2.3, 3.0]	1.76	[1.5, 2.0]
	485			1.0		
No	8	1.4	0	reference	1.00	reference
Obstructed labour				0.432		
				1.1		
Yes	39	1.6	4	[0.8, 1.6]	not entered	
	508			1.0		
No	3	1.4	0	reference		
				<0.00		
Oxytocin infusion to induce or augment labour			1			
	170			1.3		
Yes	1	1.7	5	[1.3, 1.4]	1.19	[1.1, 1.3]
	342			1.0		
No	1	1.3	0	reference	1.00	reference
				<0.00		
Gestation			1			
				3.5		
20-27 weeks	92	4.4	3	[2.9, 4.4]	1.70	[1.3, 2.2]
				2.5		
28-31 weeks	79	3.3	9	[2.1, 3.3]	1.25	[1.0, 1.6]
				1.9		
32-36 weeks	530	2.5	6	[1.8, 2.1]	1.31	[1.2, 1.5]
	431			1.0		
37-41 weeks	9	1.3	0	reference	1.00	reference
				1.8		
42+ weeks	101	2.4	4	[1.5, 2.2]	1.53	[1.3, 1.9]
				<0.00		
Method of birth			1			

	231		1.0			
Unassisted vaginal	4	1.2	0	reference	1.00	reference
			2.4			
Forceps	644	2.8	1	[2.2, 2.6]	2.09	[1.9, 2.3]
			1.3			
Vacuum	484	1.6	8	[1.2, 1.5]	1.36	[1.2, 1.5]
			0.6			
Unplanned CS (pre-labour)	27	0.8	9	[0.5, 1.0]	0.61	[0.4, 0.9]
			0.8			
Planned CS (pre-labour)	586	1.0	8	[0.8, 0.96]	0.72	[0.6, 0.8]
			1.4			
Unplanned CS (in labour)	693	1.6	0	[1.3, 1.5)	1.22	[1.1, 1.3)
			2.7			
Planned CS (in labour)	372	3.1	3	[2.4, 3.0)	1.67	[1.5, 1.9)
			<0.00			
Liveborn baby			1			
	505		1.0			
Yes	0	1.4	0	reference	1.00	reference
			2.9			
No	72	4.0	8	[2.3, 3.8)	1.88	[1.4, 2.5)
			<0.00			
Macrosomia (>=4000g)			1			
			1.6			
Yes	937	2.1	6	[1.5, 1.8]	1.82	[1.7, 2.0]
	418		1.0			
No	5	1.3	0	reference	1.00	reference
			<0.00			
Placenta accreta			1			
		58.	97.	[60.5,		[30.8,
Yes	40	0	6	157.5]	54.9	97.8]
	508		1.0			
No	2	1.4	0	reference	1.00	reference
3rd or 4th degree perineal laceration			<0.00			

Yes	261	3.7	0	[2.5, 3.2]	2.43	[2.1, 2.8]
	486		1.0			
No	1	1.4	0	reference	1.00	reference

†excludes women for whom estimated blood loss was not reported, those with missing data on age, parity, plurality or maternal country of birth, and terminations of pregnancy.

‡ Odds Ratio; § Adjusted Odds Ratio and 95% confidence intervals (CI)

Table 4: Management of labour and maternal characteristics associated with severe PPH, all women who experienced labour in Victoria, 2009-2013†

Potential risk factor	Women with severe PPH			OR		AOR	
	n	%	p	‡	CI	§	CI
Maternal characteristics							
Maternal country of birth	<0.001						
	269						
Australia	3	1.35		1.00	reference	1.00	reference
Americas	54	1.42		1.06	[0.8, 1.4]	1.09	[0.8, 1.4]
North Africa and Middle East	105	1.11		0.82	[0.7, 1.0]	0.88	[0.7, 1.1]
North East Asia	221	1.97		1.47	[1.3, 1.7]	1.63	[1.4, 1.9]
North Western Europe	107	1.18		0.88	[0.7, 1.1]	0.91	[0.7, 1.1]
Oceania and Antarctica	196	2.27		1.70	[1.5, 2.0]	1.65	[1.4, 1.9]
South East Asia	347	1.89		1.41	[1.3, 1.6]	1.63	[1.4, 1.8]
Southern and Central Asia	271	1.18		0.88	[0.8, 1.0]	0.90	[0.8, 1.0]
Southern and Eastern Europe	90	1.51		1.13	[0.9, 1.4]	1.15	[0.9, 1.4]
Sub-Saharan Africa	62	1.07		0.79	[0.6, 1.0]	0.83	[0.6, 1.1]
Maternal age (years)			0.262			not entered	

Younger than 20 years	127	1.54	1.11	[0.9, 1.3]		
	311					
20 to 34	0	1.40	1.00	reference		
35 or older	944	1.41	1.01	[0.9, 1.1]		
Socio-economic quintile			0.001			
1. Most deprived	841	1.51	1.00	[0.9, 1.1]	1.01	[0.9, 1.1]
					[0.8,	
2	726	1.34	0.89	[0.8, 1.0]	0.90	0.99]
3	796	1.51	1.00	reference	1.00	reference
4	728	1.41	0.93	[0.8, 1.0]	0.93	[0.8, 1.0]
5. Least deprived	624	1.23	0.81	[0.8, 0.9]	0.83	[0.7, 0.9]
Not available	466	1.40	0.93	[0.8, 1.0]	0.94	[0.8, 1.1]
			<0.00			
Number of previous caesareans (CS)			1			
	224					
No prior birth	3	1.62	1.39	[1.3, 1.5]	1.15	[1.1, 1.2]
	161					
Prior birth/s, no prior CS	8	1.17	1.00	reference	1.00	reference
Prior birth/s, 1 prior CS	256	1.66	1.42	[1.2, 1.6]	1.36	[1.2, 1.6]
Prior birth/s, 2 or more prior CS	24	1.44	1.23	[0.8, 1.8]	1.31	[0.9, 2.0]
Not reported	40	0.84	0.71	[0.5, 1.0]	0.63	[0.5, 0.9]
			<0.00			
Body Mass Index			1			
<18.5	93	1.10	0.88	[0.7, 1.1]	0.85	[0.7, 1.1]
	172					
18.5 to <25	1	1.25	1.00	reference	1.00	reference
				[1.04,		[1.04,
25 to <30	978	1.41	1.13	1.2]	1.12	1.2]
≥30	857	1.80	1.45	[1.3, 1.6]	1.39	[1.3, 1.5]
Not available	532	1.51	1.21	[1.1, 1.3]	1.14	[1.0, 1.3]
			<0.00			
Plurality			1			
Singleton pregnancy	407	1.38	1.00	reference	1.00	reference

		4					
Multiple pregnancy	107	3.90		2.90	[2.4, 3.5]	2.84	[2.3, 3.5]
Pregnancy and birth factors							
			<0.00				
Placental abruption			1				
		11.2			[6.6,		[5.4,
Yes	45	8		9.02	12.3]	7.51	10.5]
	413						
No	6	1.39		1.00	reference	1.00	reference
			<0.00				
Placenta praevia (with or without haemorrhage)			1				
Yes	31	5.36		4.00	[2.8, 5.8]	3.92	[2.7, 5.7]
	415						
No	0	1.40		1.00	reference	1.00	reference
			<0.00				
APH other			1				
Yes	148	2.47		1.81	[1.5, 2.1]	1.60	[1.3, 1.9]
	403						
No	3	1.38		1.00	reference	1.00	reference
Obstructed labour			0.125				
Yes	18	2.00		1.44	[0.9, 2.3]	not entered	
	416						
No	3	1.40		1.00	reference		
			<0.00				
Gestation			1				
20-27 weeks	59	3.37		2.52	[1.9, 3.3]	1.48	[1.1, 2.1]
28-31 weeks	31	2.30		1.70	[1.2, 2.4]	1.20	[0.8, 1.8]
32-36 weeks	227	1.55		1.14	[1.0, 1.3]	1.02	[0.9, 1.2]
	376						
37-41 weeks	3	1.36		1.00	reference	1.00	reference
42+ weeks	101	2.53		1.88	[1.5, 2.3]	1.60	[1.3, 2.0]
			<0.00				
Liveborn baby			1				

	412						
Yes	7	1.39	1.00	reference	1.00	reference	
No	54	3.27	2.40	[1.8, 3.1]	1.69	[1.2, 2.4]	
			<0.00				
Macrosomia (≥4kg)			1				
Yes	863	2.32	1.84	[1.7, 2.0]	1.88	[1.7, 2.0]	
	331						
No	8	1.27	1.00	reference	1.00	reference	
			<0.00				
Method of birth			1				
	231						
Unassisted vaginal	4	1.17	1.00	reference	1.00	reference	
Forceps	643	2.78	2.41	[2.2, 2.6]	2.04	[1.8, 2.3]	
Vacuum	484	1.61	1.38	[1.2, 1.5]	1.26	[1.1, 1.4]	
Unplanned CS (in labour)	27	0.82	1.41	[1.3, 1.5]	1.07	[1.0, 1.2]	
Planned CS (in labour)	693	1.64	0.70	[0.5, 1.0]	0.57	[0.4, 0.8]	
Labour-related							
			<0.00				
Oxytocin infusion in labour			1				
	170						
Yes	1	1.73	1.39	[1.3, 1.5]	1.20	[1.1, 1.3]	
	248						
No	0	1.24	1.00	reference	1.00	reference	
			<0.00				
Duration of labour			1				
				[0.7,			
< 2 hours	299	1.21	0.84	0.95]	0.96	[0.8, 1.1]	
2 to <4 hours	665	1.09	0.76	[0.7, 0.8]	0.85	[0.8, 0.9]	
	227						
4 to <12 hours	5	1.42	1.00	reference	1.00	reference	
						[1.03,	
12 to <24 hours	828	1.88	1.32	[1.2, 1.4]	1.12	1.2]	
≥24 hours	60	1.78	1.25	[1.0, 1.6]	1.07	[0.8, 1.4]	

Not reported

54

1.18

0.82

[0.6, 1.1]

1.02

[0.7, 1.4]

†excludes women for whom estimated blood loss was not reported, those with missing data on age, parity, plurality or maternal country of birth, and terminations of pregnancy.

‡ Odds Ratio; § Adjusted Odds Ratio and 95% confidence intervals (CI)

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