Maternal and perinatal outcomes for women with BMI $\geq 50\text{kg/m}^2$ in a non-tertiary hospital setting

Obstetric outcomes for women with BMI $>50\text{kg/m}^2$

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Abstract

Background: Obesity is prevalent in the Australian antenatal population, but there is scarce data on the prevalence and associated outcomes of body mass index (BMI) $\geq 50 \text{ kg/m}^2$.

Aims: To examine the prevalence and outcomes for women with BMI $\geq 50 \text{ kg/m}^2$ delivering in a non-tertiary hospital.

Materials and Methods: Retrospective cohort study of women delivering a singleton pregnancy in a non-tertiary Victorian hospital during 2011-2016. Women $> 180 \text{ kg}$ were excluded as their care was managed in a tertiary centre. Maternal and perinatal outcomes were analysed by BMI group. Statistical analysis was performed using chi-square, Kruskal-Wallis and logistic regression with a significance level of 0.05.

Results: Of the 18518 births between 2011-2016, 99.4% had a maternal BMI recorded. The prevalence of BMI $\geq 50 \text{ kg/m}^2$ was 0.5%. Highest complication rates were observed among women with BMI $\geq 50 \text{ kg/m}^2$, including gestational diabetes (29%), hypertensive disorders of pregnancy (20%) and cesarean section (48%). Of infants born to women with BMI $\geq 50 \text{ kg/m}^2$, 12% were late-preterm, 23% required special or intensive care and 20% had birth-weight $\geq 4.0 \text{ kg}$. When compared with obese women with BMI $30\text{--}49 \text{ kg/m}^2$, women with BMI $\geq 50 \text{ kg/m}^2$ were significantly more likely to develop a hypertensive disorder of pregnancy (preeclampsia aOR 3.98 (1.93-8.18), pregnancy induced hypertension aOR 3.55 (1.79-7.03)) and deliver a late pre-term infant (aOR 2.45 (1.31-4.58)).

Conclusions: The prevalence of severe maternal obesity in our non-tertiary setting is higher than previous national estimates. Women with BMI $\geq 50 \text{ kg/m}^2$ are an important subgroup of the obese obstetric population that experience high rates of complications and interventions. Health services need to respond to evolving needs of the antenatal population to achieve the best outcomes for mothers and babies.

Introduction

Obesity is a major public health concern for Australia. On a national level, the prevalence of obesity has risen over the past decades and it is now estimated that one in five women giving birth in Australia is obese¹. Obese women are well-recognized to be at increased risk of a number of obstetric complications and interventions²⁻¹³. Of particular concern is the increase in the prevalence of severe, class III obesity ($\text{BMI} \geq 40 \text{ kg/m}^2$) in pregnant women^{1, 14}.

Despite this growth in severe obesity, limited data exists for the maternal prevalence and obstetric outcomes for Australian women, particularly for those with $\text{BMI} > 50 \text{ kg/m}^2$. In international literature, maternal $\text{BMI} \geq 50 \text{ kg/m}^2$ has been reported at rates of 0.06 to 2.2%^{4,6-8,10-13,15}. An Australian surveillance study in 2010 estimated that approximately 1 in 500 pregnant women had a $\text{BMI} > 50 \text{ kg/m}^2$ and/or weight $> 140 \text{ kg}$ ⁴. Other published Australian studies are either limited by incomplete ascertainment of maternal BMI, or failure to analyse the Class III subgroup with $\text{BMI} > 50 \text{ kg/m}^2$ separately to those with $\text{BMI} 40\text{--}49 \text{ kg/m}^2$ ¹. Furthermore, outcomes for women in tertiary centres may differ from those delivering in non-tertiary settings due to the availability of specialist medical and surgical services.

Since 2009 maternal BMI has been a mandatory component of routine obstetric data collection for the Victorian Perinatal Data Collection, allowing for better ascertainment of maternal obesity rates. This study aims to (i) determine the prevalence of women with $\text{BMI} \geq 50 \text{ kg/m}^2$ in a non-tertiary Victorian setting, and (ii)

to analyse obstetric and perinatal outcomes for women according to BMI with a focus on the BMI $\geq$ 50kg/m² group.

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Materials and Methods

We performed a retrospective study of women with singleton pregnancies ≥ 20 weeks gestation delivering between January 1 2011 and December 31 2016 at a non-tertiary Victorian hospital. The hospital has level 5 maternity and neonatal service capability, caring for low and high risk obstetric patients with planned births ≥ 32 completed weeks of gestation. Data was collected from the hospital's Birthing Outcome System. Women with multiple pregnancy and those with missing BMI data were excluded. Women weighing $> 180\text{kg}$ had their care transferred to a tertiary centre as per established health service capacity criteria and were excluded from this study.

Maternal BMI was recorded at the first antenatal visit, and was rounded to the nearest whole number. BMI was divided into categories based on recommendations from the World Health Organisation¹⁵. These categories were $\leq 18\text{kg/m}^2$ (underweight), 19-24 kg/m^2 (normal weight), 25-29 kg/m^2 (overweight), 30-34 kg/m^2 (obese class I), 35-39 kg/m^2 (obese class II) and $\geq 40\text{kg/m}^2$ (obese class III). Women in the latter group were then categorized further into BMI 40-49 kg/m^2 and BMI $\geq 50\text{kg/m}^2$.

Other maternal demographic characteristics assessed included: age, weight, parity, gestational age at first antenatal visit, Indigenous status, country of birth outside Australia and preferred language spoken other than English. Data on smoking status at any stage of the pregnancy was noted. Postcode information categorized by Victorian Socioeconomic Indexes for Areas (SEIFA) using the Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD)¹⁶.

Obstetric outcomes included: induction of labour and indication (see Supplemental data 1), delivery type, epidural and general anesthetic use, shoulder dystocia, postpartum haemorrhage ($\geq 500\text{mL}$ for vaginal births, $\geq 1000\text{mL}$ for cesarean section), gestational diabetes mellitus (GDM), pregnancy induced hypertension (PIH), pre-eclampsia (PET) and third or fourth degree perineal tears.

Neonatal outcomes included birth status, gestational age at delivery (data excluded for implausible entries of >43 weeks), pre-term delivery at <32 and <36 completed weeks of gestation, birth weight, Apgar scores <7 at 1 and 5 minutes, resuscitation (intermittent positive pressure resuscitation, oxygen therapy, endotracheal intubation, external cardiac massage and ventilation, volume expanders) and admission to a special care nursery (SCN) or neonatal intensive care unit (NICU). Stillbirths were included in the analysis of neonatal outcomes.

Statistical analysis was performed using STATA 15.1 (StataCorp LLC, College Station, TX, USA). The level of significance was set at 0.05. Maternal demographic characteristics and maternal and neonatal outcomes were compared using chi-square and Kruskal-Wallis tests. Multivariable logistic regression was undertaken for several outcomes controlling for maternal age, parity, Indigenous status, maternal birthplace outside Australia and gestational age at booking. Reference groups included normal weight women and women with BMI $30\text{--}49\text{kg/m}^2$. Adjusted odds ratios (aOR) and 95% confidence intervals (CI) were calculated.

Approval to perform this study was obtained from Northern Health Office of Research and Ethics (LNR Reference No: LNRSSA/17/NH/107).

Results

Of the 18518 women with singleton pregnancies birthing at our non-tertiary hospital between 2011-2016, 18402 (99.4%) had a plausible BMI recorded at the first antenatal visit. Of these women, 92 had $\text{BMI} \geq 50 \text{ kg/m}^2$ (0.5%). There were 459 (2.5%) underweight women, 6926 (37.6%) normal weight women, 5806 (31.6%) overweight women, 2962 (16.1%) with class I obesity, 1369 (7.4%) with class II obesity and 789 (4.3%) with $\text{BMI} 40\text{--}49 \text{ kg/m}^2$. Demographic characteristics are shown in Table 1.

Of women included in the study, 5164 (28.2%) were in the most disadvantaged IRSAD group, and 216 (1.2%) were in the most advantaged group (Table 1). When excluding underweight women, a significant trend was noted between increasing BMI and lower IRSAD score.

There were nine stillbirths occurring ≥ 40 weeks gestation during the study period. Stillbirths ≥ 40 weeks made up 3% of total stillbirths in normal weight women ($n=2/72$), 11% of stillbirths in overweight women ($n=5/44$), and 4% of stillbirths in obese women ($n=2/50$). There were no stillbirths in women with $\text{BMI} > 50 \text{ kg/m}^2$.

Women with $\text{BMI} \geq 50 \text{ kg/m}^2$ had the highest rate of obstetric complications and interventions, with 29% developing GDM, 21% a hypertensive disorder of pregnancy, and 38% requiring an induction of labour, most commonly for maternal medical

complications. Epidural use was >60% and 49% required a cesarean section (CS).

Maternal outcomes are shown in Table 2a.

Among women with BMI $\geq 50 \text{ kg/m}^2$ the most common indications for emergency CS were fetal distress/cardiocotocograph (CTG) abnormalities (n=7, 33%), obstructed labour/failure to progress (n=3, 14%), and a combination of these two indications (n=3, 14%). No indication was recorded for four women (19%) and the remaining women (n=4, 19%) had other indications for emergency CS (eclampsia, pre-eclampsia, cord prolapse). Fetal distress/CTG abnormalities and/or failure to progress were responsible for 61% of emergency CS in women with BMI $\geq 50 \text{ kg/m}^2$, which was similar to the indications for emergency CS among women with BMI 40-49 kg/m^2 (64% of emergency CS performed for fetal distress/CTG abnormalities and/or failure to progress).

For infants born to mothers with BMI $\geq 50 \text{ kg/m}^2$, 20% required resuscitation and 23% required admission to SCN/NICU. Twenty percent had a birth weight $\geq 4000 \text{ g}$ and 13% were born late pre-term (between 32 and 36 completed weeks gestation).

Neonatal outcomes are shown in Table 2b.

For the 12 women with a BMI $\geq 50 \text{ kg/m}^2$ delivering a late pre-term infant, 5 were delivered early due to hypertensive disorders of pregnancy, 4 due to pre-term pre-labour rupture of membranes, 2 due to spontaneous pre-term birth and one due to CTG abnormalities.

Compared with women with a normal BMI, women with a BMI $\geq 50 \text{ kg/m}^2$ had higher odds of developing GDM (aOR 4.65(2.88-7.51)), PIH (aOR 13.60(6.64-27.85)) and

PET (aOR 11.60(5.52-24.35))), as well as requiring an induction of labour (aOR 2.17(1.40-3.37)) and CS for delivery (aOR 2.90(1.90- 4.44)). Neonates born to these mothers had higher odds of late pre-term birth (aOR 2.16(1.16-4.04)), admission to SCN/NICU (aOR 1.70(1.03-2.80)) and a birth weight 4000-4500g (aOR 3.11(1.76-5.49)) but not >4500g. (Table 3)

Table 4 shows multivariate analysis for outcomes for women with BMI $\geq$ 50kg/m² compared to women with BMI30-49kg/m². Women with BMI $\geq$ 50kg/m² were significantly more likely than less obese women to develop a hypertensive disorder of pregnancy (PET aOR 3.98(1.93-8.18), PIH aOR 3.55(1.79-7.03)) and deliver a late pre-term infant (aOR 2.45(1.31-4.58)).

Discussion

With over 99% complete data on maternal BMI over a six-year period, our study is the first contemporary Australian study to report on the prevalence and outcomes of severe maternal obesity in a non-tertiary hospital. Our study confirms that obesity is common among Australian obstetric patients and that increasing BMI is linked to a number of pregnancy and neonatal complications²⁻¹³. It also provides point estimates of these complications for the severely obese obstetric patient delivering in a non-tertiary hospital.

Over 28% of our mothers were obese at their first antenatal visit, and 1 in 200 (0.5%) had a BMI $\geq$ 50kg/m². This is higher than the previous national estimate in a 2017 report by the Australian Institute of Health and Welfare, in which 20% of pregnant women were classified as obese¹⁷. The higher rate detected in our study may be due to

the high proportion of mothers from socially-disadvantaged backgrounds, a known risk factor for elevated BMI¹⁸.

Of women with BMI $\geq 50 \text{ kg/m}^2$, 29% developed GDM, higher than rates reported elsewhere of 11-21.1%⁶⁻⁷. Hypertensive disorders of pregnancy were noted in 20.65% of women with a BMI $\geq 50 \text{ kg/m}^2$, which lies within the range of international estimates (10.1-23%) for women in this BMI category^{8, 12}. As both GDM and hypertensive disorders of pregnancy necessitate additional obstetric surveillance and interventions, these women require substantial resources to be invested in their antenatal care.

The rate of CS for women with a BMI $\geq 50 \text{ kg/m}^2$ was 48.91%, over double the rate seen in normal weight women in this cohort. This figure falls within the rates quoted elsewhere (39.2-60.6%)^{6,7}. A high rate of CS for these women may have clinical implications, with studies noting that up to 30% of severely obese mothers delivering via CS develop a wound infection, placing them at risk of a longer hospital admission, readmission and surgical intervention^{19, 20}. This has important implications for the provision of additional resources and special attention to discharge planning for these women. The reduced rate of instrumental delivery with increasing maternal BMI may be explained by an anticipatory birth planning to avoid shoulder dystocia²¹ and may have contributed to high CS rate.

Neonates born to the mother with BMI $\geq 50 \text{ kg/m}^2$ are also at risk of adverse outcomes. The proportion of infants with a birth weight $\geq 4000 \text{ g}$ is lower for this cohort compared to that described elsewhere^{6,12}. This may be explained by the proportion (13.4%) of infants born pre-term.

When compared to women with BMI 30-49 kg/m², those with a BMI $\geq$ 50 kg/m² remained more likely to deliver a late-preterm infant. A meta-analysis²² noted a similar trend with increased rates of pre-term birth among mothers with increasing severity of obesity. However, unlike our study, those included in the meta-analysis did not specifically analyse women with BMI $>$ 50 kg/m².

The links between increased severity of maternal obesity and pre-term birth has implications for the long-term outcomes of the infant. An Australian study by Bentley et al²³ highlights this, finding that early planned births ($<$ 39 weeks) are associated with increased risk of poor childhood development during the school aged years.

Our unadjusted stillbirth rate of 0.91% is comparable with annual unadjusted stillbirth rates for Victoria, which ranged from 0.77- 0.95% over our study period^{24, 25}. While some studies have found an increase in the risk of stillbirth with increasing maternal BMI¹, others^{3, 9} including this study have not. Obesity is however, a documented risk factor for stillbirth²⁶, and while it may not be the strongest factor, due to its prevalence it is one of the most common. Despite this, stillbirth is a relatively uncommon outcome in Australia, and our sample size was underpowered to detect a significant difference in stillbirth by maternal BMI.

The prevalence of BMI $\geq$ 50 kg/m² in this study (0.5%), lies within the range reported elsewhere in international studies 0.06-2.2%^{6-8, 10-14}. However, due to methodological differences, care needs to be taken when comparing these results. Past studies excluded women of a non-obese BMI^{11, 12, 15} or over- and underweight women¹³ as well as differing in the time at which maternal BMI data was collected, with some

studies using an estimation of pre-pregnancy weight^{6, 7, 11} the last recorded weight prior to delivery¹⁰ or any weight during pregnancy giving a BMI $\geq 50 \text{ kg/m}^2$ ^{4, 8}.

Australian guidelines recognize that maternal BMI should ideally be calculated pre-pregnancy, they also recognize that this data is often unknown, and in which case it is suitable to calculate maternal BMI at the first antenatal visit²⁷ as was done in this study.

The strengths of this study lie with the large sample size and almost complete recording of maternal BMI at the first antenatal appointment, making this the most complete analysis for a contemporary Australian cohort. One of the major limitations was the exclusion of women with a body weight $\geq 180 \text{ kg}$ due to the service capacity of our hospital. As women with weight $\geq 180 \text{ kg}$ received antenatal care and delivered at a tertiary centre we were unable to collect their outcomes due to the scope of our single site ethics approval. The numbers of these women would be expected to be very small, and since the aim of this study was to examine the outcomes of obstetric patients delivering in a non-tertiary unit, we did not consider these outcomes essential. While our results therefore, may reflect a small underestimation of the rates of severe obesity in our catchment region, they provide an accurate picture of obstetric outcomes for our level 5 centre.

We noted a high rate of missing data for maternal smoking during pregnancy in our hospital database. Smoking is a factor with known risk for adverse pregnancy outcomes and is a factor that many other studies controlled for in multivariate analysis^{1-4, 6, 8-10, 13}. We speculate that this field was selectively completed by the booking midwife only if the woman was a smoker, but this was unable to be verified.

Obtaining better compliance with data collection for this important risk factor is an area for future practice improvement in our centre.

Finally, gestational weight-gain was not examined in this study as the routine weighing of women at term gestation was not performed during the study period. Gestational weight gain is recognized as an important influence on obstetric and neonatal outcomes, independent of pre-pregnancy BMI, and is an area for future research²⁸.

The Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG) recommends that health care facilities have defined pathways for the management and care of obese pregnant women²⁷. It is advised that adequate and experienced healthcare providers and infrastructure should be provided for the care of women with a BMI>40kg/m².²⁷ Similarly, Safer Care Victoria encourages health services to assess their capacity to safely care for women with BMI>30kg/m², highlighting that low-level maternity care is not appropriate for these women²⁹. In 2018 the Opal Clinic was established at our hospital site to provide a multidisciplinary clinic specifically catering for women with a BMI>40kg/m² and for those who have had bariatric surgery, regardless of their BMI. This clinic offers obstetrician-lead care with dietician, midwifery, and anaesthetic input, as well as structured clinical pathways for assessment of fetal growth, maternal comorbidities and specialist referral when required.

The prevalence of maternal obesity in our study was higher than previous national estimates, highlighting its importance for current clinical practice. One in three women giving birth in our non-tertiary hospital are obese, with 1 in 200 being severely obese. Women with a BMI $\geq 50 \text{ kg/m}^2$ had the highest rates of adverse outcomes and intervention, including maternal medical complications, Cesarean section and late prematurity. This study highlights the challenges that the obesity epidemic creates for obstetric care in non-tertiary hospitals and provides timely data to inform future health services planning.

Tables

Table 1: Demographic characteristics of women in the study sample by BMI category (kg/m^2)

Table 2a: Maternal outcomes by maternal BMI (kg/m^2)

Table 2b: Neonatal outcomes by maternal BMI (kg/m^2)

Table 3: Multivariate analysis for obstetric outcomes associated with maternal BMI (kg/m^2), compared to women with BMI 19-24 kg/m^2 .

Table 4: Multivariate analysis for obstetric outcomes associated with a maternal BMI $\geq 50 \text{ kg/m}^2$, compared to obese women with BMI 30-49 kg/m^2

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Table 1: Demographic characteristics of women in the study sample by BMI category (kg/m²) (n= 18 402)

Maternal characteristic	Total (n=18 408)	≤18 (n=459)	18-24 (n=6926)	25-29 (n=5806)	30-49 (n=5119)	≥50 (n=92)	p-value
Median age, years (IQR)	29 (7)	26 (7)	28 (7)	29 (7)	29 (8)	31 (9)	<0.001
Median weight, kg (IQR)	69 (21.5)	47.5 (6)	58.5 (8.5)	71 (9.5)	91 (19)	144.5 (22)	<0.001
Primiparous	7486 (40.68)	250 (54.47)	3354 (48.43)	2296 (39.55)	1566 (30.59)	20 (21.74)	<0.001
Median gestational age at booking visit (IQR)	16 (7)	14 (5)	15 (6)	16 (8)	16 (9)	18 (12)	<0.001
Aboriginal or Torres Strait Islander	(n=18 341) 252 (1.37)	(n=457) 10 (2.19)	(n=6903) 79 (1.14)	(n=5787) 56 (0.97)	(n=5102) 100 (1.96)	7 (7.61)	<0.001
Born outside Australia	(n=18 379) 9289 (50.54)	(n=457) 254 (55.34)	(n=6918) 3967 (57.34)	(n=5797) 3143 (54.22)	(n=5113) 2167 (42.50)	28 (30.43)	<0.001
English not preferred language	(n=15 718) 3284 (20.98)	(n=409) 81 (23.72)	(n=5912) 1374 (23.24)	(n=4952) 1128 (22.78)	(n=4372) 698 (15.76)	(n=73) 3 (4.11)	<0.001
Smoked during pregnancy†	(n= 2583) 2078 (11.30)	(n=65) 54 (11.76)	(n=795) 661 (9.54)	(n=790) 636 (10.95)	(n=917) 715 (13.97)	(n=16) 12 (17.39)	0.098
SEIFA IRSAD Quintile‡	(n=18 401)		(n=6935)				
1 (lowest)	5191 (28.21)	144 (31.37)	1884 (27.20)	1649 (28.40)	1485 (29.01)	29 (31.52)	<0.001
2	8110 (44.07)	200 (43.57)	3090 (44.61)	2596 (44.71)	2181 (42.61)	43 (46.74)	
3	1851 (10.06)	42 (9.15)	700 (10.11)	551 (9.49)	551 (11.96)	7 (7.61)	
4	2990 (16.25)	67 (14.6)	1160 (16.75)	953 (16.10)	798 (15.59)	12 (13.04)	
5 (highest)	216 (1.17)	6 (1.31)	91 (1.31)	75 (1.29)	43 (0.84)	1 (1.09)	

Results are presented n(%), unless otherwise indicated, due to rounding, column values may not equal to 100.

Significant (p<0.05) characteristics are indicated in **bold** text

†smoking data was assumed to only to be collected for patients with positive smoking history during the pregnancy, percentage calculations used the total number of women in each BMI group as the denominator

‡analysis for trend excluded women with BMI≤18kg/m²

Table 2a: Maternal outcomes by maternal BMI (kg/m²)

Outcome	Total (n=18 402)	≤18 (n=459)	19-24 (n=6926)	25-29 (n=5806)	30-49 (n=5119)	>50 (n=92)	p-value
GDM	2713 (14.74)	23 (5.01)	659 (9.51)	888 (15.29)	1116 (21.80)	27 (29.35)	<0.001
PIH	347 (1.90)	1 (0.22)	71 (1.03)	81 (1.40)	184 (3.59)	10 (10.87)	<0.001
PET	365 (1.98)	6 (1.31)	94 (1.36)	100 (1.72)	156 (3.05)	9 (9.78)	<0.001
Induction of labour†	5662 (30.77)	115 (25.05)	1937 (27.97)	1747 (30.09)	1828 (35.71)	35 (38.04)	<0.001
- Existing maternal	186 (3.30)	1 (0.87)	49 (2.53)	63 (3.61)	71 (3.88)	2 (5.71)	0.064
- Pregnancy	1700 (30.02)	15 (13.04)	397 (20.50)	524 (29.99)	744 (40.70)	20 (57.14)	<0.001

induced							
- Neonatal	1288 (22.75)	48 (41.74)	549 (28.34)	371 (21.24)	315 (17.23)	5 (14.29)	<0.001
- Other	1407 (24.85)	33 (28.70)	579 (29.89)	422 (24.16)	368 (20.13)	5 (14.29)	<0.001
pregnancy							
- Post-dates	865 (15.28)	15 (13.04)	276 (14.25)	304 (17.40)	268 (14.66)	2 (5.71)	0.025
- Other	216 (3.81)	3 (2.61)	87 (4.49)	63 (3.61)	62 (3.39)	1 (2.86)	0.398
Delivery type							
- CS (total)	5369 (29.18)	85 (18.52)	1636 (23.62)	1710 (29.45)	1893 (36.98)	45 (48.91)	<0.001
- Elective CS	2355 (12.80)	28 (6.10)	650 (9.38)	720 (12.40)	933 (18.22)	24 (26.09)	
- Emergency CS	3014 (16.40)	57 (12.42)	986 (14.24)	990 (17.05)	960 (18.75)	21 (22.83)	
- Vaginal	10932 (59.41)	297 (64.71)	4353 (62.85)	3408 (58.70)	2829 (55.26)	45 (48.91)	
- Instrumental	1919 (10.43)	73 (15.90)	869 (12.55)	625 (10.76)	350 (6.84)	2 (2.17)	
- VBAC	146 (0.79)	3 (0.65)	55 (0.79)	51 (0.88)	37 (0.72)	0 (0.00)	0.789
- Vaginal Breech	36 (0.20)	1 (0.22)	13 (0.19)	12 (0.21)	10 (0.20)	0 (0.00)	0.993
Shoulder dystocia†	343 (2.63)	7 (2.11)	117 (2.21)	123 (3.00)	94 (2.91)	2 (4.26)	0.085
Birth anaesthesia							
- Epidural	7752 (42.13)	204 (44.44)	2522 (36.41)	2450 (42.20)	2517 (49.17)	59 (64.13)	<0.001
- General	401 (2.18)	10 (2.18)	126 (1.82)	120 (2.07)	141 (2.75)	4 (4.35)	0.006
anaesthesia							
	(n=18 388)		(n=6924)	(n=5800)	(n=5113)		
PPH	2027 (11.02)	52 (11.33)	775 (11.19)	631 (10.88)	563 (11.01)	6 (6.52)	0.686
Perineal tear (3 rd , 4 th degree) ‡	327 (2.51)	10 (3.00)	157 (2.97)	105 (2.56)	55 (1.70)	0 (0.00)	0.006

Results are presented n(%), unless otherwise indicated, due to rounding, column values may not equal to 100.

Statistically significant (p<0.05) are indicated in **bold** text

† See Supplemental Data for indications included within each category for induction of labour

‡ Analysis for women with vaginal delivery

Table 2b: Neonatal outcomes by maternal BMI (kg/m²)

Outcome	Total (n=18 402)	≤18 (n=459)	18-24 (n=6926)	25-29 (n=5806)	30-49 (n=5119)	≥50 (n=92)	p-value
Median gestational age at delivery in weeks (IQR)	39.72 (1.75)	39.49 (1.97)	39.73 (1.73)	39.73 (1.52)	39.48 (2.00)	39.00 (2.12)	<0.001
Prematurity, weeks	(n=18 401)		(n=6925)				
- <32	176 (0.96)	2 (0.44)	84 (1.21)	43 (0.74)	47 (0.92)	0 (0.00)	0.041
- 32+0 to 36+6	1004 (5.46)	31 (6.75)	383 (5.53)	300 (5.17)	278 (5.43)	12 (13.04)	0.012
Stillbirth	167 (0.91)	1 (0.22)	72 (1.04)	44 (0.76)	50 (0.98)	0 (0.00)	0.176
Female infants	(n=18 387)		(n=6916)	(n=5805)	(n=5115)		
	9024 (49.10)	229 (49.89)	3463 (50.07)	2781 (47.91)	2509 (49.05)	42 (45.65)	0.166
Birth weight	(n=18 393)		(n=6923)	(n=5804)	(n=5115)		
- Median							

weight, grams (g), (IQR)		3150 (590)	3260 (610)	3370 (640)	3470 (650)	3665 (665)	<0.001
-	≤2500g†	469 (2.55)	28 (6.10)	227 (3.28)	136 (2.34)	78 (1.52)	0 (0.00)
-	4000-4500g	1453 (7.90)	16 (3.49)	384 (5.55)	450 (7.75)	587 (11.48)	16 (17.39)
-	≥4500g	241 (1.31)	0 (0.00)	34 (0.49)	64 (1.10)	141 (2.76)	2 (2.17)
Apgar score <7 at		(n=18 397)	(n=6924)	(n=5803)			
-	1 minute	1726 (9.38)	30 (6.54)	622 (8.98)	539 (9.29)	519 (10.14)	16 (17.39)
-	5 minutes	408 (2.22)	7 (1.53)	172 (2.48)	115 (1.98)	113 (2.21)	1 (1.09)
Admission to		(n=18 240)	(n=457)	(n=6859)	(n=5764)	(n=5068)	
NICU/SCN		3071 (16.84)	74 (16.19)	1111 (16.20)	928 (16.10)	937 (18.49)	21 (22.83)
Neonatal resuscitation		2141 (11.63)	50 (10.89)	748 (10.80)	673 (11.59)	652 (12.74)	18 (19.57)

Results are presented n(%), unless otherwise indicated, due to rounding, column values may not equal to 100.

Statistically significant (p<0.05) are indicated in **bold** text.

†for term neonates, includes n=1 stillbirth

Table 3: Multivariate analysis for obstetric outcomes associated with maternal BMI(kg/m²), compared to women with BMI19-24kg/m².

Outcome	<18	25-29	30-49	≥50
GDM	0.55 (0.36-0.84)	1.71 (1.53-1.92)	2.95 (2.64-3.29)	4.65 (2.88-7.51)
PIH	0.21 (0.03-1.51)	1.41 (1.02-1.95)	3.84 (2.88-5.10)	13.60 (6.64-27.85)
PET	0.99 (0.43-2.30)	1.46 (1.09-1.97)	2.91 (2.21-3.84)	11.60 (5.52-24.35)
Induction of labour	0.83 (0.67-1.05)	1.20 (1.11-1.31)	1.73 (1.59-3.88)	2.17 (1.40-3.37)
CS (total)	0.79 (0.61-1.01)	1.33 (1.23-1.45)	1.95 (1.79-2.12)	2.90 (1.90- 4.44)
CS (emergency)	0.84 (0.63-1.14)	1.35 (1.22-1.50)	1.75 (1.58-1.95)	2.29 (1.36-3.84)
Admission to SCN/NICU	0.99 (0.76-1.30)	1.01 (0.91-1.11)	1.25 (1.13-1.40)	1.70 (1.03-2.80)
Birth weight ≥4500g	N/A	2.16 (1.41-3.30)	4.93 (3.34-7.27)	3.36 (0.78-14.38)
Birth weight 4000- 4500g	0.63 (0.38-1.05)	1.39 (1.20-1.60)	2.09 (1.81-2.40)	3.11 (1.76-5.49)
Late pre-term delivery (32+0 to 36+6 weeks gestation)	1.18 (0.78-1.77)	0.87 (0.74-1.01)	0.88 (0.75-1.04)	2.16 (1.16-4.04)

Results presented as aOR (95% CI)

Adjusted for maternal age, parity, Indigenous status, born outside of Australia and gestational age at booking

Statistically significant (p<0.05) are indicated in **bold** text.

Table 4: Multivariate analysis for obstetric outcomes associated with a maternal BMI≥50kg/m², compared to obese women with BMI30-49kg/m²

Outcome	BMI≥50 kg/m ²
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GDM	1.57 (0.98-2.54)
PIH	3.55 (1.79-7.03)
PET	3.98 (1.93-8.18)
Induction of labour	1.26 (0.81-1.94)
CS (total)	1.49 (0.98-2.28)
CS (emergency)	1.31 (0.77-2.12)
Admission to SCN/NICU	1.35 (0.82-2.23)
Birth weight $\geq 4500\text{g}$	0.68 (0.16-2.81)
Birth weight 4000-4500g	1.49 (0.85-2.62)
Late pre-term delivery (32+0 to 36+6 weeks gestation)	2.45 (1.31-4.58)

Results presented as aOR (95% CI)

Adjusted for maternal age, parity, Indigenous status, born outside of Australia and gestational age at booking

Statistically significant ($p < 0.05$) are indicated in **bold** text.

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