ADVERSE PERINATAL EVENTS OBSERVED IN OBESE PREGNANT WOMEN IN THE METRO WEST REGION

by:

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DECLARATION

I, LUIS A GADAMA hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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ABBREVIATIONS

AOR	**Adjusted odds ratio**
BANC	**Basic Antenatal Care**
BMI	**Body Mass Index**
CHC	**Community Health Centre**
CI	**Confidence Intervals**
GSH	**Groote Schuur Hospital**
GMOU	**Guguletu Midwife Obstetric Unit**
HIV/AIDS	**Human Immunodeficiency Virus / Acquired Immune Deficiency Syndrome**
Kgs	**Kilograms**
m^2	**square metre**
MMH	**Mowbray Maternity Hospital**
MOU	**Midwife Obstetric Unit**
MPMOU	**Mitchells Plain Midwife Obstetric Unit**
NICU	**Neonatal Intensive Care Unit**
OR	**Odds Ratio**
PPH	**Post Partum Haemorrhage**
UCT	**University of Cape Town**
UK	**United Kingdom**
USA	**United States of America**
WHO	**World Health Organization**

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ABSTRACT

Background. Obesity is increasing globally and is defined as a Body Mass Index (BMI) over 30 kgms/m². It's prevalence in the Metro West Maternity service is unknown.

Objective . To assess the prevalence of obesity and determine its association with adverse perinatal and maternal outcomes among pregnant women in the Metro West Region, Cape Town, South Africa

Study Design. This was a retrospective observational study that compared perinatal outcomes in women with normal pregnancyBMI to outcomes in women with high pregnancy BMI.

Setting. Mitchells Plain and Guguletu Midwife Obstetric Units, Mowbray Maternity Hospital and Groote Schuur Hospital, Metro West Region, Cape Town, South Africa

Population. A total of 970 pregnant women divided into BMI groups that had their first antenatal booking visit between January and April 2011.

Methods. A list of folder numbers was compiled from the antenatal booking registry at the two MOUs. From the list, maternal folders were then traced through the CLINICOM tracking system, MOU delivery registers, antenatal clinic transfer registers and labour ward transfer registers to find place of delivery or outcome of pregnancy. Maternal and perinatal characteristics were then extracted from the folders into the data collection sheet and data was analysed by STATA. Descriptive statistics included proportions with percentages and median with interquartile ranges. Inferential statistics included Chi-squared tests, Fisher Exact tests, Kruskal Wallis test, univariate and multivariable logistic regressions.

Main outcome measures. Perinatal outcomes (stillbirth, macrosomia, shoulder dystocia, 5 minute Apgar Score less than 7, congenital abnormalities) observed in obese and morbidly obese compared to normal BMI pregnant women.

Results. Eight hundred and twenty pregnant women delivered at the MOUs, 120 at the level 2 institution and 30 at a tertiary institution. The 970 included 197 overweight women and 389 obese women, of which 118 were morbidly obese. The prevalence of obesity in the study population was 40.4%. Higher maternal age was associated with increased BMI (p=0.0001). HIV prevalence was 15.5% and obese women were more likely to be HIV positive (*p*=0.000).Perinatal outcomes of macrosomia (p < 0.000), shoulder dystocia (p< 0.000), perinatal death (p<0.000), Neonatal Intensive Care Unit (NICU) admission (p< 0.000), 5 minute Apgar score < 7 (p= 0.008), and congenital abnormalities (p<0.000) were all significantly more common in the morbidly obese women when compared with those with a normal BMI. The unadjusted odds ratios for preterm delivery were 0.71 (95% CI, 0.36-1.42), 1.27 (95% CI, 0.74-2.16) and 2.66 (95% CI, 1.49-4.77) among overweight, obese and morbidly obese pregnant women respectively compared to normal weight pregnant women. Having accounted for age, parity, hypertension in pregnancy, gestational diabetes and HIV, morbidly obese women had high significant adjusted odds ratios for macrosomic deliveries 9.2(4.61-18.55), perinatal deaths 9.0 (3.04-27.04), shoulder dystocia 36.6 (8.94-149.40), ICU admission 10.25 (4.82-23.95), preterm delivery 2.3 (1.2-4.15) and perinatal events 12.34 (7.02-21.69).Maternal outcomes of caesarean section (p<0.000), third or fourth degree perineal tears (p=0.005), occurrence of hypertension and gestational diabetes in pregnancy (p<0.0000), and preterm delivery (p = 0.001) were significantly more common in the

morbidly obese group. In the morbidly obese pregnant women, 74.6% attained a vaginal delivery compared to 96.8% in the normal BMI group. Thromboembolic events (p = 0.251) were not significantly higher among the high BMI group compared to the normal BMI group.

Conclusion The prevalence of obesity in pregnancy in our population was high, and was associated with adverse perinatal outcomes, especially in the morbidly obese group. Adverse maternal outcomes were also more likely to occur in morbidly obese women than in women with a normal BMI.

Keywords Body mass index, obesity, pregnancy, adverse perinatal outcomes, Cape Town, South Africa

INTRODUCTION

The prevalence of obesity in the general population has risen to such an extent that it is now considered a worldwide epidemic. This has been recognized by the World Health Organization (WHO) [1]. This increase has a direct impact on women of reproductive age[1]. Over one billion adults worldwide are estimated to be overweight, with 400 million of these classified as obese.[1,2] Approximately half of the women of reproductive age in the United States of America (USA) are either overweight or obese.[1,2] South Africa has not been spared by this epidemic, as according to the South African Demographic Health Survey of 2003, 57% of women are classified as being either obese or overweight.[3,4] Major contributing factors towards the high prevalence of obesity in South Africa have been a shift in dietary intake to that of a higher fat intake, and generally reduced levels of physical activity. In addition, few overweight black women view themselves as overweight, and more recently, there is a social stigma of associating thinness to HIV/AIDS.[3,4] The major public health impact of this obesity epidemic is the resultant increase in the prevalence of medical conditions such as type 2 diabetes and hypertension. This has consequently strained health care budgets, as instead of preventing these conditions, there is now a need to treat more affected people.[4]

Obesity in pregnancy poses a great challenge, as it has been associated with undesirable outcomes. The recent finding of obesity occurring in one in five women at antenatal booking in the United Kingdom (UK) is concerning. [5] In the United States of America (USA), the prevalence of obesity during pregnancy increased significantly from 7 to 24

percent between 1991 and 2003, and currently is at 30.5%, whilst in South Africa, Basu et al found the prevalence of obesity in pregnancy to be 44%. [6-8]

The WHO has approved the use of body mass index (BMI) for the assessment of obesity in pregnancy.[1] The justification for this is that BMI does not change significantly until the third trimester, and other assessment tools of obesity like skin fold thickness are not reliable in pregnancy as they are affected by alterations in body composition during pregnancy. BMI is calculated using maternal booking weight measurements in kilograms (kg) divided by maternal booking height in meters squared (m^2) and expressed as kg/m^2. It is then classified in to the 5 groups as tabulated below: [1,6-8]

BMI (Kg/m^2)	CLASS
≤18.49	Underweight
18.5-24.9	Normal- ideal
25.0-29.9	Overweight
30.0-39.9	Obesity
≥40.0	Morbidly obese

Many studies have shown that obesity in pregnancy is associated with a wide spectrum of adverse pregnancy outcomes. These can be classified as maternal or perinatal. Adverse perinatal outcomes include an increased risk of congenital abnormalities; specifically neural tube and cardiac defects, an increased risk of preterm delivery, and higher rates of stillbirth.[9-28] There is a higher prevalence of fetal macrosomia

(birthweight ≥4.0kg), which in turn can result in shoulder dystocia and subsequent trauma to both mother and baby. [29-30] Fetal macrosomia has also been shown to be a predisposing factor in the development of childhood obesity.[25-26]

Adverse maternal outcomes include an increased risk of gestational hypertension and diabetes, a higher rate of caesarean section due to slow and prolonged labour, and increased postpartum complications such as postpartum haemorrhage, infection and thromboembolic events. [9-15,29-46]

Obesity in the general population has been declared a worldwide epidemic and its effects in pregnancy have been extensively studied in the western world. There is little data so far from sub Saharan Africa and in our setting in Cape Town, hence we decided to assess the impact of obesity on pregnancy outcomes.

LITERATURE REVIEW

Maternal and perinatal outcomes in obese pregnant women have been extensively studied in different populations and some of the literature is shown below.

Assessment of obesity

BMI is considered to be the best indicator of obesity in general and in pregnancy. It is the most frequently used tool for assessing obesity in pregnancy in research studies and is a better indicator of obesity than weight alone [5-8]. In an ideal setting BMI should be measured between 10 -12 weeks gestation because this is the best indicator of pre-pregnancy weight. [6-8] However, in poor resource settings like sub-Saharan Africa, many

women book for antenatal care after the first trimester; on average at 28 weeks[8] and 69% of pregnant women have only one antenatal care visit in their entire pregnancy which is usually late on in pregnancy. [8,47-48] . This means that booking weight may reflect weight gain in pregnancy as well as pre pregnancy weight. This would be a particular problem in the third trimester since this is the period when maternal weight gain would have been greatest. [6-8] Given that the majority of women book in the second trimester, BMI estimation in this trimester, although having limitations, may be the only way of acquiring a baseline BMI measurement in pregnant women in our setting. A further limitation of obesity using BMI is that many antenatal clinics may not have weighing scales or height measuring devices. [47-48]

Perinatal outcomes

Maternal obesity has been associated with a small increase in the absolute rate of certain congenital anomalies, and this risk has been shown to rise with an increase in maternal weight.[9-19] The underlying pathophysiology is unknown, but it is postulated that there is an altered nutritional environment for fetal development in obese women. A systematic review (39 studies) and meta-analysis (18 studies) showed that the odds of neural tube defects in obese women compared to those with normal BMI was 1.87 [95% Confidence Interval (CI) 1.62-2.15], and that of cardiovascular anomalies was 1.30 [95% CI 1.12-1.51]. [16] Another meta-analysis (12 case-control and cohort studies) showed that the risk of neural tube defects increased significantly with maternal weight. Compared with normal weight women, the odds of having a child with a neural tube

defect were as follows: overweight women [Odds Ratio (OR) 1.22; 95% CI 0.99-1.49], obese women (OR 1.70; 95%CI 1.34-2.15) and severely obese women (OR 3.11; 95% CI 1.75-5.46).[17] The findings in these studies however, are confounded by several limitations. These include a variable degree of antenatal detection of congenital anomalies between different centres, failure to diagnose and adjust for maternal diabetes, and the use of different systems in the classification of obesity. There is also a significant impairment of adequate ultrasound visualisation of fetal anatomy as BMI increases and this is mostly marked for cardiac and craniospinal structures.[17-19] Maternal obesity also increase the likelihood that more than one ultrasound scan will be required for a fetal anomaly survey, thereby impacting on the service provision and is costly for the patient.[17-19]

Population based cohort studies have reported an increased risk of preterm birth in obese women. Women with pre-pregnancy BMI $\geq$ 30kg/m² were at increased risk of preterm delivery (delivery before 37 completed weeks gestation) compared to lean women, with an OR of 1.6 (95% CI 1.2-2.1). This increased risk remained significant when women with diabetes, hypertension or preeclampsia were analysed separately (OR1.5; 95% CI 1.1-2.1) [20] The above finding was echoed by a meta-analysis which showed that the risk of preterm delivery increased with higher grades of obesity. Adjusted odds ratio (AOR) on overweight, obese and morbidly obese compared to normal weight were: 0.85 (95% CI: 0.80-0.92), 1.33 (95% CI: 1.12-1.57) and 2.27 (95% CI: 1.76-2.94) respectively.[18] The increase in the risk of preterm delivery could be explained by obesity related

medical and antenatal complications that often lead to elective delivery rather than an intrinsic predisposition to spontaneous preterm birth.[9-15,21]

Pre-pregnancy obesity and maternal weight gain during pregnancy both play a vital role in determining infant birth weight. Several studies have shown that there is a linear relationship between increasing pre-pregnancy weight and birth weight. [22] Macrosomia (birth weight > 4.0kg) is commonly seen in obese women, and it is a recognised risk factor for the development of shoulder dystocia, which can subsequently result in both maternal and fetal trauma.[9-15,22-24] In shoulder dystocia even if there is an expedited delivery, brachial plexus injuries and bone fractures are still encountered.[9-15] Epidemiological studies have shown a continuum from macrosomia at birth to the development of childhood obesity and its associated metabolic complications of diabetes and hypertension.[25-26] Several cohort studies have shown that pre-pregnancy weight loss to a normal BMI reduces the risks of having a macrosomic infant.[27]

An association between perinatal mortality and high BMI has also been documented. In a meta-analysis (nine controlled trials) it was shown that overweight and obese pregnant women experienced significantly more stillbirths than normal weight women: overweight women unadjusted OR 1.47(95% CI 1.08-1.94), and obese women unadjusted OR 2.07(95% CI 1.59-2.74).[28] Several hypotheses have been postulated to explain the association, and these include: a) higher rates of diabetes and hypertension seen in obese women compared to non-obese and these conditions contribute significantly to occurrence of stillbirths, b) metabolic changes associated with obesity, c)

decreased awareness of fetal movements, d) nocturnal apnoea with transient oxygen desaturation. Several studies have shown that even if there is adjustment for diabetes and hypertension as major confounding factors to stillbirth, the stillbirth rates are still high in the obese population. This has been attributed to fetal growth restriction associated with histological placental dysfunction seen in obese women.[9-15,28]

Due to small numbers in some of the perinatal outcomes observed some authors have resorted to have a composite score when assessing adverse perinatal events for obese pregnant women. [9-15] An example for a composite score of adverse perinatal events would include one or more of the following: macrosomia, shoulder dystocia, congenital abnormalities and perinatal deaths.

Maternal outcomes

In the United States (US), studies have shown that in obese pregnant women there is a 6 to 12 percent increase in gestational diabetes as compared to a 2 to 4 percent increase in the general population. [9-15] Due to the association between obesity and gestational diabetes, prenatal care units in the US screen all obese pregnant women for gestational diabetes. The US studies show that there is an increased risk of type 2 diabetes in obese women due to an exaggerated increase in insulin resistance. Prenatal units in the US also screen for pre-gestational diabetes using the following risk factors: marked obesity, personal history of gestational diabetes, glycosuria, strong family history of diabetes. [29] Gestational diabetes usually resolves postpartum however obese women have a two fold

increased prevalence of subsequent type 2 diabetes compared with women with a normal BMI. [30]

An association between obesity and hypertensive disorders in pregnancy has been consistently reported. In addition, maternal weight and BMI are independent risk factors for preeclampsia and other hypertensive disorders. [31] A review of 13 cohort studies comprising nearly 1.4 million women found that the risk of preeclampsia doubled with each 5 to 7kg/m² increase in pre-pregnancy BMI. [32] This observation persisted in studies that excluded women with chronic hypertension, diabetes mellitus, multiple pregnancy and other confounders. Weight loss pre-pregnancy significantly reduces the risk of preeclampsia as was evidenced in women who underwent bariatric surgery.[27] The mechanism whereby obesity imparts an increased risk for preeclampsia is not clearly understood. Current hypotheses suggest that pathophysiological changes associated with obesity related cardiovascular risk such as insulin resistance, hyperlipidaemia and subclinical inflammation are responsible for the increased incidence of preeclampsia in obese pregnant women. [31-34]

Cohort studies have illustrated that obese women have prolonged labours. In a study of 509 nulliparous women undergoing induction of labour it was shown that as maternal weight increased, the rate of cervical dilatation decreased and the induction to delivery interval lengthened. [35] A similar relationship was echoed in a cohort of 612 nulliparous women who delivered following spontaneous labour. [36] The mean duration of labour from a cervical dilatation of 4 cm to 10 cm was significantly longer for both

overweight and obese women, compared to normal weight women (7.5, 7.9 and 6.2 hours respectively). A study that measured intrauterine pressures during labour showed that obese women did not have a significant reduction in baseline uterine contractility or uterine pressures generated during valsalva compared to non-obese control. [37] The active phase of labour was significantly longer in obese women, suggesting that active phase rather than second stage labour characteristics may be more significantly impacted by maternal weight. This theory has been supported by studies which have shown that samples of myometrium taken from obese women at caesarean delivery contracted less well in vitro than myometria obtained from normal weight women. [38] Although there is currently inadequate data to establish weight based criteria for labour management, it has been suggested that, providing maternal and fetal status are reassuring, the clinician could adjust his or her expectations of normal labour progress to allow for a longer active phase and second stage of labour in obese women.

Due to prolonged labour in obese women there is increased frequency in caesarean delivery for cephalopelvic disproportion or failure to progress. [35,36,39] It has also been hypothesized that obesity may lead to dystocia due to increased soft tissue deposition in the maternal pelvis. [40] Pre-pregnancy obesity and excessive weight gain before or during pregnancy contribute to an increased probability of caesarean delivery. [40-42] Caesarean delivery in obese pregnant women is associated with a number of perioperative concerns which are: difficulty in placement of regional anaesthesia, difficult intubation following failed regional anaesthesia with concerns of aspiration, emergency delivery, prolonged incision to delivery interval, postpartum haemorrhage (blood loss >1000ml), longer

operative times, wound infection, thromboembolism and endometritis. [43-44] The relative contribution of maternal, intrapartum and surgical factors to perioperative morbidity in the obese population is not clearly defined. One study suggested that difficulties encountered when operating in obese women lead to lapses in surgical technique and inadequate haemostasis, with a resultant increase in wound complications. [43-44]

Obesity is a risk factor for thromboembolism both in the antenatal and postnatal periods. In first world countries thromboembolic events is responsible for a high proportion of maternal deaths. [45] Of the 33 women who died from pulmonary embolism in the UK between 2003 and 2005, 12 (36%) were obese. Although data is limited, obesity has been shown to be associated with a high risk of pulmonary embolism (AOR 14.9, 95% CI: 3.0-74.8) and deep vein thrombosis (AOR 4.4, 95% CI: 1.6-11.9) compared to normal BMI. [43-45] Thromboprophylaxis guidelines have been instituted to prevent such events in the general population as well as in the pregnant population. They start by ambulation, adequate hydration, thromboembolic deterrent stockings and providing low molecular heparin as per risk score analysis. [43-45]

Obesity is associated with increased rate of postpartum haemorrhage (PPH).[9-15] Policy guidelines have been drafted that recommend all obese women to have active management of third stage of labour as PPH is one of the preventable causes of maternal deaths. A population based cohort study of over a million women with singleton pregnancy demonstrated that the risk of PPH due to uterine atony increased rapidly with increasing BMI, however no link was found with retained placenta. For morbidly obese

women there was an increased risk for PPH following a normal delivery (OR 1.23, 95% CI: 1.04-1.45) compared with women with normal BMI. This was even more pronounced when assisted vaginal delivery was instituted (OR 1.69, 95% CI: 1.22-2.34).[46]

Pre-conception weight loss

In an ideal setting, a normal weight should be achieved prior to pregnancy, as this would avoid potentially negative outcomes. Although health care experts support the idea that obese women should lose weight preconceptionally, this has not been tested in a clinical trial. The following obstacles have been encountered when trying to promote preconception weight loss: a) It has been noted that nearly half of pregnancies in the USA are unplanned, hence no preconception counselling is instituted, b) Contraception can be used to delay pregnancy while trying to lose weight but oestrogen containing contraceptives are contraindicated in obese hypertensive women, and c) It has been reported that the efficacy of contraception in obese clients is reduced, which could consequently result in unplanned pregnancies.[49] If pre-pregnancy weight is not controlled in the near future, the prevalence of obesity in pregnancy will rise further.

RATIONALE OF THE STUDY

Obesity has been declared a worldwide epidemic and although its effects in pregnancy have been extensively evaluated in well to do resource settings, there is less data from poorly resourced settings such as sub Saharan Africa. It was our proposal to assess the

impact of obesity on perinatal outcomes in pregnant women booking for antenatal care from the Guguletu, and Mitchell's Plain residential areas. The study also planned to estimate the prevalence of obesity in these two drainage areas and to describe adverse maternal outcomes associated with obesity.

STUDY OBJECTIVES

The study aimed to:

a) Measure the prevalence of obesity in all women who book for antenatal care from Guguletu and Mitchell's Plain drainage areas

(b) Compare the incidence of adverse perinatal outcomes in pregnant women with high BMI compared to those with normal BMI

(c) Describe the incidence of adverse maternal events in women with high BMI and women with normal BMI

METHODS

Study design

This was a retrospective observational study that compared perinatal outcomes in women with normal pregnancy BMI to outcomes in women with high pregnancy BMI.

Study population

The study population included pregnant women residing in the Guguletu and Mitchell's Plain residential areas who booked at Guguletu MOU (GMOU) and Mitchell's Plain MOU (MPMOU) during January to April 2011. Mitchell's Plain is a middle income

community with a population of 398 650, of which 66.2% are coloured, 33% black African, and the remainder being white, Indian or Asian. Guguletu is a low socioeconomic status community with a population of 80 277. This is made up of predominantly 98.8% black African, and 1.1% coloured ethnic groups. In the two study populations, at least 51% are female. [50]

Study setting

The majority of women in these two areas book for antenatal care at the local MOU or Basic AnteNatal Care (BANC) primary clinic. These two midwife obstetric units (MOUs) provide maternity care services at primary level with a combined total of about 6000 deliveries per annum. A further 4500 per annum deliver at Mowbray Maternity Hospital which is the referral secondary level hospital for these two MOUs. Tertiary care is catered for by Groote Schuur Hospital, accounting for approximately 1500 deliveries as referrals per annum from these two MOUs. A small number of women who have had problems in a previous pregnancy book directly at secondary level (MMH) and tertiary level (GSH). Of the larger group that book at the primary level MOU or BANC clinic, women who are assessed to be higher risk and/ or develop complications during antenatal care will be referred for delivery at MMH or GSH depending on the severity of the problem. Additionally some women will be referred on to secondary level or tertiary level hospital intrapartum or postpartum. Annual delivery statistics indicate that approximately 48% of deliveries occur at primary level, 37% at secondary level and 15% at tertiary level

Inclusion criteria

Pregnant women residing in Guguletu and Mitchells Plain who booked at Guguletu and Mitchells Plain MOUs in the first or second trimester, with a singleton pregnancy and gestational age less than 30 weeks. Gestational age was assessed by dating from the last first day of the last normal menstrual period and/or obstetric ultrasound scan done during the antenatal care.

Exclusion criteria

Pregnant women with pre-existing hypertension and diabetes, multiple pregnancies, and miscarriages before 20 weeks gestation were excluded from the comparative part of the study since these conditions are known to have an independent effect on perinatal outcomes. Underweight women as defined by BMI ≤18.49 were also excluded from the comparative part of the study as underweight is also a potential confounder on adverse perinatal outcomes.

Process of data collection

A list of folder numbers was retrospectively compiled from the antenatal booking registry of all pregnant women who booked for antenatal care at the specified sites during the study period (1 January to 30 April 2011). From the list, maternal folders were tracked by using the CLINICOM electronic tracking system, MOU delivery registers, antenatal clinic transfer registers and labour ward transfer registers to find the place of delivery or outcome of the pregnancy. Once folders were identified, maternal and neonatal characteristics were assigned a study number as a mother/ infant pair.

Mother infant pairs were retrospectively tracked to the end of the pregnancy. All required characteristics were extracted and entered into the data collection sheet and later on filtered as to the inclusion and exclusion criteria of the study. The tracking system enabled us to follow women that were referred to secondary or tertiary level care in their pregnancy as well as those that were referred back to the MOUs.

Maternal data was extracted from the maternity case record books, and admission and delivery registers kept at the delivery facility. Maternal characteristics that were extracted included age, gravidity, parity, height and weight at booking, gestational age at booking, HIV status, obstetric scan done in pregnancy, gestation age at delivery, pre-existing medical conditions noted at booking (hypertension and diabetes), development of hypertension and diabetes in pregnancy, mode of delivery including the indication, occurrence of perineal tears, postpartum haemorrhage (PPH), diagnosis of thromboembolic events, prolonged hospital stay (> 5 days) and diagnosis of sepsis within 5 days postpartum. See appendix A.

Corresponding neonatal data was extracted from neonatal folders and delivery registers. Neonatal characteristic extracted included sex, birth weight, 5 minute Apgar scores at delivery, occurrence of shoulder dystocia, congenital anomalies (neural tube and cardiac defects), perinatal deaths (stillbirth and neonatal death within 7 days of life) and admission to the neonatal intensive care unit (NICU) with indications included. (Apgar score <7 in 5 minutes, macrosomia, complications from shoulder dystocia) See appendix A.

Study outcomes

As noted from the literature, adverse perinatal outcomes can be evaluated individually or as a composite score in view of small numbers in some of the events. In our study the primary study outcome was a composite of the following perinatal events:

1) Perinatal death (stillbirth or neonatal death within 7 days of life),

2) Macrosomia (birth weight > 4.0kgs in our setting),

3) Shoulder dystocia (prolongation of head to body delivery time of > 60 seconds after gentle traction has failed), [9-15]

4) Five minute Apgar score < 7,

5) Congenital abnormalities (neural tube and cardiac defects).

Secondary end points looked at the prevalence of obesity in the study population and maternal adverse events that occurred after women had been enrolled into the study. Maternal adverse events included the development of hypertension and diabetes in pregnancy, caesarean section, assisted delivery, third and fourth degree perineal tears, PPH, thromboembolism and prolonged hospital stay of more than 5 days.

See appendix A for the data collection forms.

Sample size

The sample size calculation based on the occurrence of the composite outcome showed the required sample to be 1109 based on a 95% confidence level with a power of study set at 80%. An interim analysis was planned to assess the effect of obesity on perinatal outcomes. We anticipated that in the study population 25% would be classified as obese and in the obese group there would be 10% prevalence of adverse perinatal outcomes and the odds of adverse event was 2.1 in the obese group.[51-52] From the unexposed group (normal BMI) we anticipated that there would be a 5% prevalence of the perinatal outcomes. Our exposed group was the high BMI categories and the unexposed/ control group was the normal BMI group.

Statistical analysis

Data was analysed by STATA MP 11: StataCorp. 2009. *Stata Statistical Software: Release 11*. College Station, TX: StataCorp LP.

Comparisons were drawn between the normal BMI and the increased BMI groups (overweight, obese and morbidly obese). Descriptive and inferential statistics were used for the data analysis. Chi-square and / or Fisher exact tests were computed to assess the effect of maternal BMI on perinatal and maternal outcomes. We examined the effect of age on increase in BMI by Kruskall-Wallis test. Univariate logistics regression models were used to assess the unadjusted odds ratio of an event (maternal or perinatal) occurring in the respective BMI categories and having accounted for possible confounders multivariate logistics regression models were employed to give the adjusted odds ratios (AOR). Statistical analysis used normal BMI as the reference and p value < 0.05 was taken as level of significance. Variables used in the models were maternal age,

parity, gestational age at delivery, weight and height, perinatal and maternal outcomes. In particular age, parity, hypertension, gestational diabetes and HIV are known to influence perinatal outcome and the influence of these were adjusted for in the statistical analysis.

Ethics

Ethical approval was granted by the Human Research Ethics Committee of the University of Cape Town (reference number HREC 463/2012 see appendix B) and permission to conduct the research at the respective delivery units was obtained from the research committee of the Provincial Government of the Western Cape (2012 RP 150 see appendix C).

Strict confidentiality was practised and no maternal direct identifiers like names and contact details were entered in the working data sheet. Maternal folders were not taken out of the delivery units. Study participants were assigned study numbers throughout the study period and transfer of participants' information from folders was only done by the study investigator. Since the study was retrospective in nature and involved folder review and no patient contact, no consent was needed from the participants.

RESULTS

During the study period 1350 women were noted to have been entered into the booking registry from January to the end of April 2011, of which 150 folders were missing. Of the 1200 folders that were reviewed 230 were excluded as per the exclusion criteria in the methods section (14 preexisting medical problems, 22 were underweight, 53 missing variables, 141 booked after 30 weeks) and 970 folders were analysed for the comparative component of the study (see Figure 1). From the analysed folders, 820 of the participants delivered at the MOUs, 30 delivered at the tertiary institution and 120 delivered at secondary level care as shown by figure 1.

An interim analysis was done on the first 1350 folders of the women that booked at the two MOUs and the final folders of 970 that were used for the comparative analysis showed significant adverse effect of obesity on perinatal outcomes hence we did not proceed to look for the remainder of the sample size (1109). Possible explanations for the interim analysis findings was that we underestimated the prevalence of obesity in our population as well as the effect of maternal obesity on perinatal outcomes as will be revealed by the results below.

Figure 1. Number of folders reviewed and the application of inclusion and exclusion criteria

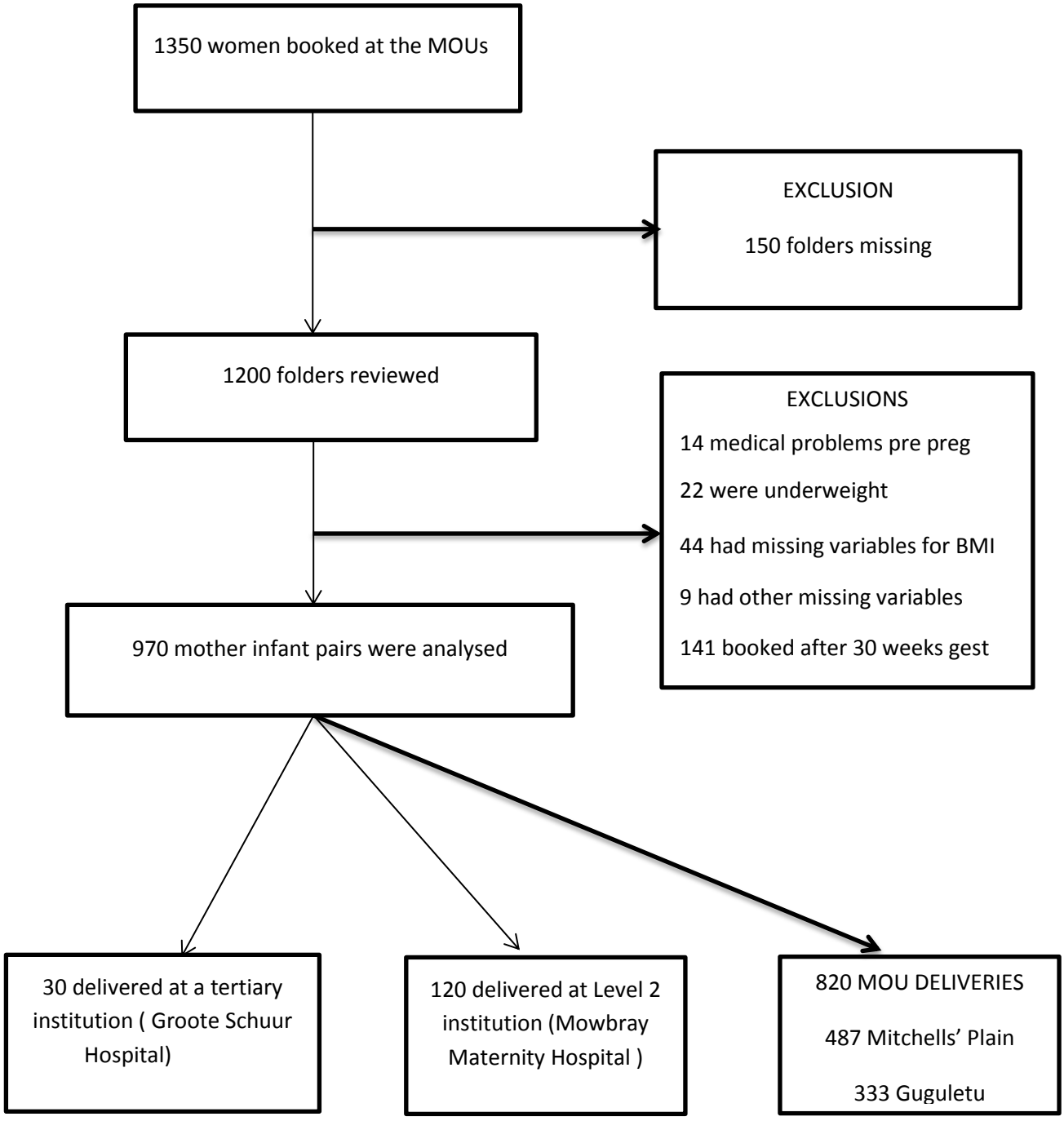
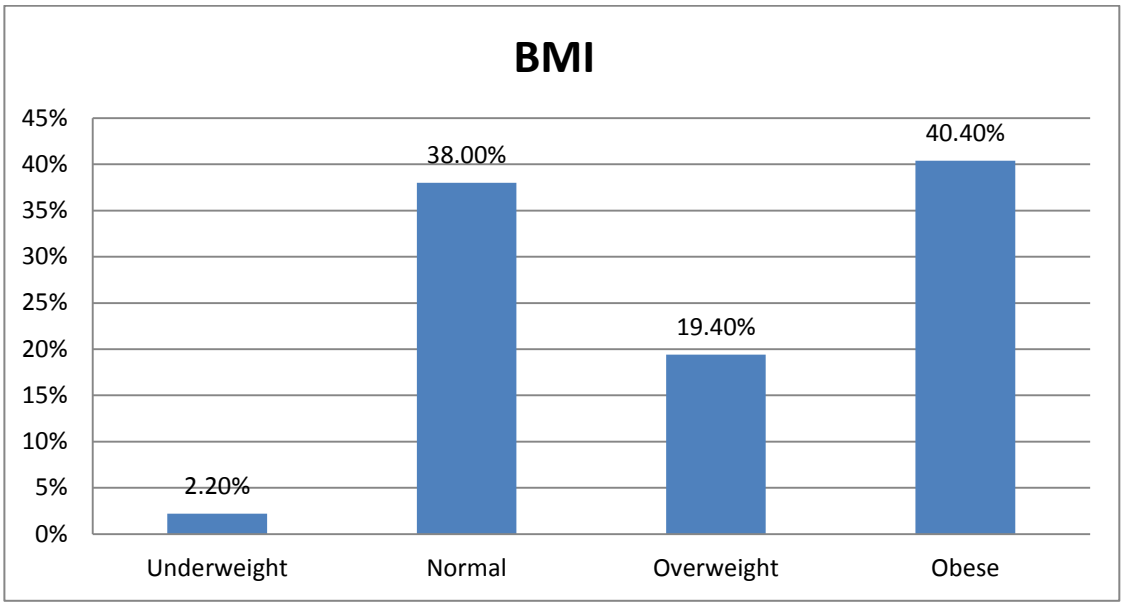


Table one shows the prevalence of obesity in the study population to be 40.4%; and provides a breakdown of the study group into BMI categories. For calculating the obesity rate the denominator used was 1015 which included all categories of BMI (970 plus 22 underweight women) and the 14 women with medical problems noted at the booking visit and the 9 women with other missing variables but had weight and height documented. Twenty two (2.2%) women were classified as underweight, 386 (38.0%) had normal BMI, 197 (19.4%) were overweight and 410 (40.4%) were obese. (Table 1 and Figure 2). Comparing the two MOUs, MPMOU had more obese women than GMOU 40.6% vs 35.4% and GMOU had more overweight women than MPMOU 20.2% vs 15.7%. (Table 1)

Table 1: Prevalence of obesity in the study population.

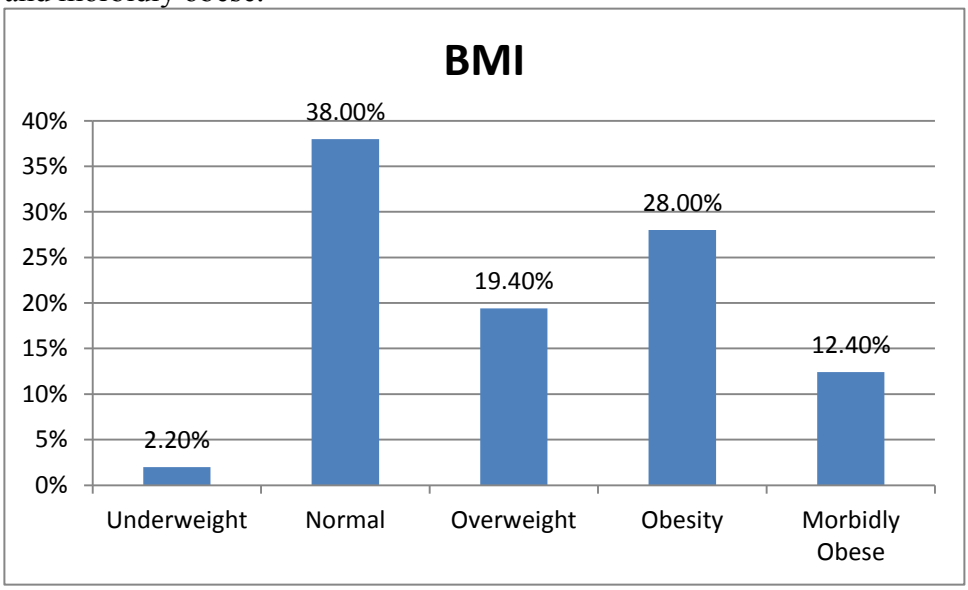
BMI	MPMOU n(%)	GMOU n(%)	Group Total n (%)
Underweight	15(3.0)	7(1.0)	22(2.2)
Normal	200(40.7)	186(31.4)	386(38.0)
Overweight	77(15.7)	120(20.2)	197(19.4)
Obese	200(40.6)	210(35.4)	410(40.4)
TOTAL	492 (100)	593(100)	1015(100)

Figure 2: Prevalence of obesity in the study group



When the obese group was split into obesity and morbidly obese, our study showed that 12.4% were morbidly obese.(Figure 3).

Figure 3: Prevalence of obesity in the study cohorts with obese group split into obesity and morbidly obese.



For the comparative analysis of perinatal and maternal outcomes in women with high BMI compared to normal BMI, the underweight women were excluded from the analysis; giving a total group of 970 that were further analysed .The following figures and tables refers to the further analysis of 970 cases.

Table 2. Maternal characteristics for the study cohort

Study sample descriptives n= 970	
Maternal characteristics	n (%)
Age (years)median (IQR)	25(21-29)
Parity,	
Primiparous	247(25.5)
One previous pregnancy	378(40.0)
More than one previous pregnancy	345(35.5)
Gestational age at booking	
Less than 20 wks	419(43.0)
20-29.9 wks	551(57.0)
Gestational age at delivery	
Less than 37 completed wks	95(9.8)
38-41+ wks	875(90.2)
At least one obstetric scan	826(85.2)
Mode of delivery	
Vaginal delivery	866(89.3)
Instrumental delivery	6(0.6)
Caesarean section	98(10.1)
Hypertension in pregnancy	40(4.1)
Gestational diabetes	17(1.8)
HIV	
Positive	150(15.5)
Negative	820(84.5)
Perineal tears	
≤ second degree	960(99.0)
≥ third degree	10(1.0)
PPH	53(5.5)

Median age of the study cohorts was 25 (IQR 21-29), 247(25.5%) of the participants were primiparous, 378 (40.0%) had one previous pregnancy and 345 (35.5%) had more than one previous pregnancy. Median age was used as the data was not normally distributed. On gestational age at booking 419 (43.0%) participants booked when they were less than 20 weeks and 551 (57.0%) booked between 20 -29.9 weeks of gestation. At least 826 (85.2%) of the study participants had an obstetric scan during their entire pregnancy. Gestational age at booking was assessed by menstrual dates if they were sure or an early obstetric scan was used to give an estimate date of delivery. 95 (9.8%) of the women had a preterm delivery, 866 (89.3%) attained a vaginal delivery with the incidences of instrumental and caesarean section delivery being 0.6% and 10.1% respectively. From the study population 150 (15.5%) women were HIV positive and 1.0% of the women sustained at least a third degree perineal tear. 4.1% of the study population developed hypertension after the booking visit and 1.8 % developed gestational diabetes in pregnancy.(see Table 2)

The data on median age at booking assessed by Kruskal- Wallis test showed that higher BMI was significantly associated with a higher age ($p = 0.0001$) as shown by table 3 and figure 3. Post hoc pairwise tests (Mann-Whitney) also showed that a difference existed in BMI for older women and this was statistically significant when women with normal BMI category were compared to overweight, obese and morbidly obese groups. The differences were also seen when overweight women were compared to obese and morbidly obese groups and these differences were statistically significant. (all calculated p- value < adjusted ref p-value of 0.0083, see table 4). However when obese group of

women were compared to the morbidly obese, the difference was not statistically significant. (calculated p > adjusted ref p value of 0.008)

Table3. Showing age distribution within BMI categories (p= 0.0001 by Kruskal Wallis test.)

Age by categories of BMI						
BMI	**N**	**Minimum**	**Maximum**	**Median**	**25th Percentile**	**75th Percentile**
Normal	384	14	42	22	20	26
Overweight	197	14	44	25	21	29
Obese	271	16	45	27	23	32
Morbidly Obese	118	16	41	26	24	31
Total	970	14	45	25	21	29

Figure 4: Box and whisker plot indicating median values, IQR and range of age for each category of BMI.

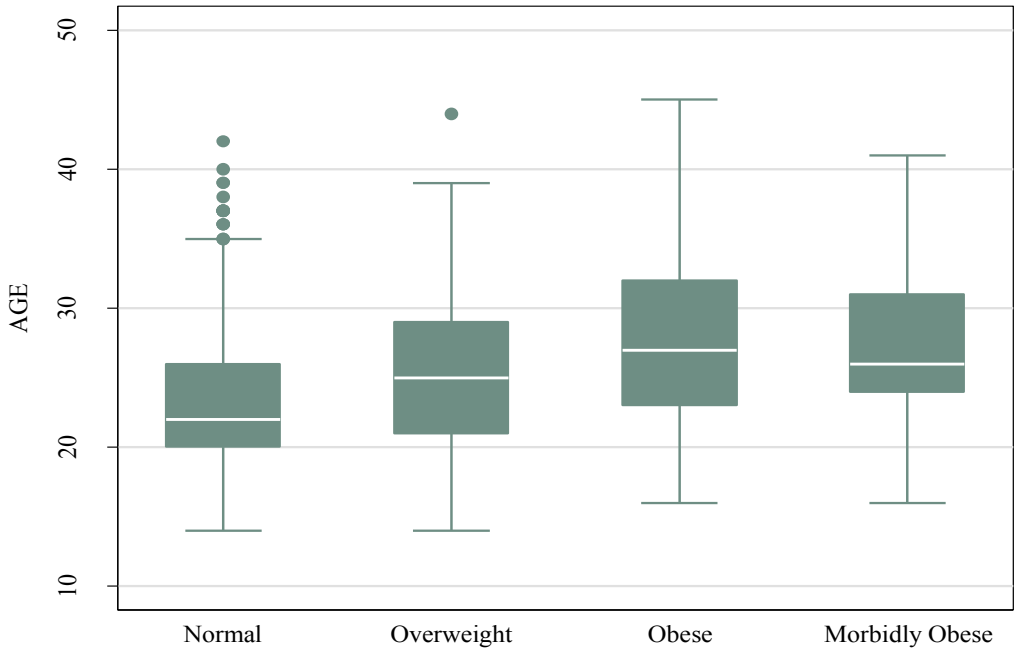
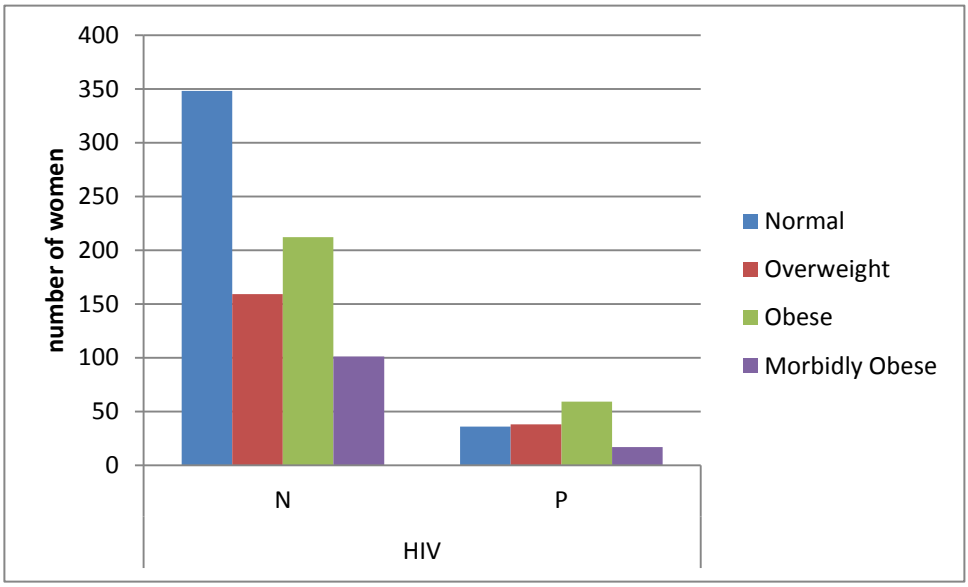


Table 4. Further analysis by Mann-Whitney pairwise tests showing age differences within BMI categories.

BMI Category	Vs.	Test statistic	P-value	Adjusted Ref p-value
Normal	Overweight	z = -5.081	<0.0001	0.008333
	Obese	z = -9.844	<0.0001	0.008333
	Morbidly Obese	z = -7.592	<0.0001	0.008333
Overweight	Obese	z = -4.068	<0.0001	0.008333
	Morbidly Obese	z = -3.032	0.0024	0.008333
Obese	Morbidly Obese	z = 0.535	0.5926	0.008333

15.5% of the study cohort were HIV positive (Table 2) and among the HIV positive group obese women were more likely to be HIV positive. This association was statistically significant (*P*=0.000) see figure 5.

Figure 5: Prevalence and association of HIV and BMI where N depicts HIV negative and P for HIV positive subjects.



***P*=0.000**

Perinatal outcomes

Table 5. Perinatal outcomes by Body Mass Index Categories

	Body Mass Index Category				
Outcome	**Normal n=378**	**Overweight n=197**	**Obese n=271**	**Morbidly obese n=118**	**P**
Birth weight ≥4kg	16(4.2)	11(5.6)	34(12.6)	29(24.6)	0.000
Shoulder dystocia	3(0.8)	1(0.5)	5(1.9)	11(9.3)	0.000
Perinatal death[n]	6(1.6)	0	7(2.6)	12(10.2)	0.000
NICU admission	11(2.8)	5(2.5)	11(4.0)	25(21.2)	0.000
Apgar, 5 min < 7	6(1.6)	2(1.0)	6(2.2)	8(7.6)	0.008‡
Congenital abnormalities†	0	0	3(1.1)	11(9.3)	0.000‡
At least one Perinatal event[ɳ]	30(7.8)	15(7.6)	52(19.2)	55(46.6)	0.000

‡Analysis was done using Fischer's exact test

† Cardiac and neural tube defects

[n]Still births and early neonatal deaths

[ɳ] Cumulative outcome

This study showed that birth weight ≥ 4kg, shoulder dystocia, perinatal death, NICU admission, 5 minute Apgars < 7, congenital abnormalities and perinatal events were significantly more frequent as BMI categories increased from normal to morbidly obese. (all variables $p < 0.05$, see Table 5).

When 3 BMI categories were analysed [normal, overweight and obese (BMI≥30)] obese women had unadjusted odds ratios for macrosomia 4.4(2.52-7.85), perinatal death3.24 (1.23-8.19), shoulder dystocia 5.45 (1.57-18.85), ICU admission 3.46 (1.73-6.90), preterm delivery 1.66 (1.04-2.65) and perinatal event 4.48(2.9-6.91) which were all significant (see Table 6).

Table 6. Unadjusted odds ratios and 95% confidence intervals for perinatal outcomes for high maternal BMI in comparison to normal BMI, where obese included all BMI ≥ 30kg/m²

	Maternal BMI at booking		
	normal weight (n=384)	**Overweight (n=197)**	**Obese (n=389)**
Birth weight ≥4kg (n=970)	1	1.36(0.62-2.99)	4.44(2.52-7.85)
Perinatal death (n=970)	1	¥	3.24(1.23-8.19)
Shoulder dystocia (n=970)	1	0.65(0.07-6.27)	5.45(1.57-18.85)
ICU admission (n=970)	1	0.88(0.30-2.58)	3.46(1.73-6.90)
preterm delivery (n=970)	1	0.71(0.36-1.42)	1.66(1.04-2.65)
perinatal event (n=970)	1	0.97(0.51-1.85)	4.48(2.9-6.91)

¥ overweight subjects not used as they were no perinatal deaths observed in this cohort

Splitting BMI ≥ 30 into obese and morbidly obese as per WHO criteria unadjusted odds ratios were significant for all outcomes in the morbidly obese group with normal BMI used as a reference category (see Table 7). However the unadjusted odds ratios with

95% CI in the obese category for perinatal death, shoulder dystocia, ICU admission, preterm delivery were not significant [1.67(0.55-5.03), 2.39 (0.56-10.08), 1.44 (0.61-3.36), 1.27 (0.74-4.53) respectively] but the unadjusted odds ratios with 95% CI for macrosomia 3.30 (1.78-6.11) and perinatal events 2.80 (1.73-4.53) were significant in the obese group (see Table 7). Unadjusted odds ratios for neonatal outcomes in the overweight group were not significantly different from the normal weight category (see Table 7).

Table 7. Unadjusted odds ratios and 95% confidence intervals for perinatal outcomes for high maternal BMI in comparison to normal BMI with BMI ≥ 30kg/m² split into obesity and morbidly obese

	Maternal BMI at booking			
	normal weight (n = 384)	**overweight (n = 197)**	**obesity (n = 271)**	**morbidly obese (n = 118)**
Birth weight≥4kg (n=970)	1	1.36 (0.62-2.99)	3.3 (1.78-6.11)†	7.49 (3.90-14.40)†
Perinatal death (n=773)	1	¥	1.67 (0.55-5.03)	7.13 (2.62-19.45)†
Shoulder dystocia (n=970)	1	0.65 (0.07-6.27)	2.39 (0.56-10.08)	13.06 (3.58-47.64)†
ICU admission (n= 970)	1	0.88 (0.30-2.58)	1.44 (0.61-3.36)	9.11 (4.33-19.19)†
Preterm delivery (n=970)	1	0.71 (0.359-1.42)	1.27 (0.74-2.16)	2.66 (1.49-4.77)†
perinatal events (n=970)	1	0.97 (0.51-1.85)	2.80 (1.73-4.53)†	10.3 (6.13-17.32)†

† Indicates unadjusted odds ratio that was statistically significant
normal weight used as a reference category
¥ overweight subjects not used as they were no perinatal deaths observed in this cohort,

Having accounted for age, parity, hypertension in pregnancy, gestational diabetes and HIV, morbidly obese women had high significant adjusted odds ratios for macrosomic deliveries 9.2(4.61-18.55), perinatal deaths 9.0 (3.04-27.04), shoulder dystocia 36.6 (8.94-149.40), ICU admission 10.25 (4.82-23.95), preterm delivery 2.3 (1.2-4.15) and perinatal events 12.34 (7.02-21.69)(see Table 8). However, though perinatal outcomes in

the morbidly obese group were statistically significantly higher compared to normal BMI, they had wide confidence intervals. Obese women were 4.7 times more likely to have a macrosomic delivery, 5.5times more likely to encounter shoulder dystocia and 3.9 times more likely for a perinatal event to happen when compared to the normal weight group and all these observations were statistically significant. However odds for perinatal death (2.48), ICU admission (1.71) and preterm delivery (1.1) were not significant in the obese group (see Table 8). Though the adjusted odds for preterm delivery were 31% lower in overweight group this was not statistically significant (see table 8).

Table 8. Adjusted odd ratios and 95% confidence interval for perinatal outcomes for high maternal BMI in comparison to normal BMI

	Maternal BMI at booking			
	normal weight (n = 384)	**overweight (n = 197)**	**obesity (n = 271)**	**morbidly obese (n = 118)**
Birth weight ≥4kg *	**1**	**1.69 (0.76-3.77)**	**4.71 (2,45-9.06)**	**9.24 (4.61-18.55)**
Perinatal death[ĥ]	**1**	**£**	**2.48 (0.78-7.86)**	**9.07 (3.04-27.04)**
Shoulder dystocia*	**1**	**0.97 (0.10-9.50)**	**5.49 (1.25-24.16)**	**36.56 (8.94-149.40)**
ICU admission*	**1**	**0.97 (0.32-2.86)**	**1.71 (0.70-4.17)**	**10.75 (4.82-23.95)**
Preterm delivery*	**1**	**0.69 (0.34-1.37)**	**1.10 (0.68-1.95)**	**2.26 (1.20-4.15)**
Perinatal event*	**1**	**1.14 (0.59-2.20)**	**3.9 (2.31-6.55)**	**12.34 (7.02-21.69)**

Adjusted odds ratio (AOR) having accounted for age, parity, hypertension and gestational diabetes in pregnancy and HIV. Normal weight used as the reference category. $P < 0.005$

£ no perinatal death was observed in the overweight group

*n= 970

[ĥ] n= 773

Maternal outcomes

Table 9. Maternal outcomes by Body Mass Index categories

	Body Mass Index Category (kg/m²)				
Outcome	**Normal** *(n=384)*	**Overweight** *(n=197)*	**Obesity** (n=271)	**Morbidly Obese** (n=118)	**P**
Mode of delivery	n (%)	n (%)	n (%)	n (%)	0.000
Vaginal delivery	372(96.8)	175(88.8)	231(85.2)	88(74.6)	
instrumental delivery	1(0.3)	1(0.5)	3(1.1)	1(0.9)	
caesarean section	11(2.9)	21(10.7)	37(13.7)	29(24.6)	
Perineal tears‡	2(0.5)	0	3(1.1)	5(4.2)	0.005
Gestational age at delivery†	32(8.3)	12(6.1)	28(10.3)	23(19.5)	0.001
Medical problems in pregnancy[n]	8(2.0)	22(11.2)	22(8.1)	21(17.8)	0.000
Thromboembolism	0	0	2(0.7)	0	0.251

‡ third or fourth degree tears

† less than 37 complete weeks

[n] hypertension in pregnancy and gestational diabetes

In terms of mode of delivery, 98 (10.1%) of the 970 women were delivered by caesarean section (Table 2) Morbidly obese women had a higher incidence (24.6%) of caesarean delivery which was significant (p= 0.000) (Tables 9). As the BMI category increased the proportion of preterm deliveries also increased from 6.1% in overweight category to 19.5% in morbidly obese women and this was significant (p= 0.001). There was also a significantly increased number of third degree perineal tears with higher BMI (p= 0.005, Table 9). The incidence of thromboembolism in high BMI groups was not significant in this study (p=0.251, Table 9). This study cohort showed an increase in maternal medical problems in pregnancy with an increase in BMI which was statistically significant (p = 0.000, Table 9).

Table 10. Unadjusted odds ratios and 95% confidence intervals for maternal outcomes for high maternal BMI in comparison to normal BMI with all BMI ≥ 30kg/m² classified as obese

	Maternal BMI at booking		
	Normal weight (n=384)	**Overweight (n=197)**	**Obese (n=389)**
Hypertension in pregnancy	1	2.38(0.72-7.90)	6.11(2.34-15.95)
Gestational diabetes	1	¤	4.74(1.35-16.63)
Mode of delivery	1	4.06(1.91-8.60)	7.00(3.63-13.48)
Perineal tear ≠	1	¥	2.5(0.76-11.40)

¤ no gestational diabetes was observed in the overweight group.

¥ overweight group did not sustain third degree perineal tears

≠ at least third degree perineal tear

Unadjusted odds ratios with 95% CI for developing hypertension, gestational diabetes in pregnancy, sustaining at least third degree perineal tears and being delivered by caesarean section among the obesity group (BMI ≥ 30) were 6.1 (2.34-15.95), 4.7 (1.35-16.63), 2.6 (0.62-8.76), 7.0 (3.6-13.48) respectively. See table 10. Morbidly obese women were more likely to develop hypertension (7.8 times), gestational diabetes (11.8 times), sustain third degree perineal tears (8.5 times) and be delivered by caesarean section (11.2 times) when compared to the normal weight women and this was statistically significant though with wide confidence intervals (see table 11).

Table 11. Unadjusted odds ratios and 95% confidence intervals for maternal outcomes for high maternal BMI in comparison to normal BMI with BMI ≥ 30kg/m² split into obesity and morbidly obese

	Maternal BMI at booking			
	normal weight (n=384)	**Overweight (n=197)**	**Obesity (n=271)**	**morbidly obese (n=118)**
Hypertension in pregnancy	1	2.38(0.72-7.90)	5.39(2.00-14.71)	7.80(2.65-22.92)
Gestational diabetes	1	¤	1.9(0.42-8.57)	11.76(3.18-43.49)
Mode of delivery	1	4.06(1.91-8.60)	5.42(2.71-1085)	11.15(5.36-23.57)
Perineal tears ≠	1	¥	2.10(0.36-12.88)	8.50(1.62-44.15)

¤ no gestational diabetes was observed in the overweight group.

≠ at least third degree perineal tear.

¥ overweight group did not sustain third degree perineal tears

Having adjusted for age, parity and HIV, morbidly obese women had high significant adjusted odds ratio for developing hypertension in pregnancy 7.80 (2.65-22.92), gestational diabetes 6.16 (1.57-24.20), being delivered through caesarean section 9.16 (4.34-19.31) and sustaining a third degree perineal tear 9.33 (1.98-56.23). Though obese women had a 23% lower risk of developing gestational diabetes this was not statistically significant (Table 12).

Table 12. Adjusted odds ratios and 95% confidence intervals for maternal outcomes for high maternal BMI in comparison to normal BMI with BMI ≥ 30kg/m² split into obesity and morbidly obese

	Maternal BMI at booking			
	Normal weight (n=384)	**overweight (n=197)**	**obesity (n=271)**	**morbidly obese (n=118)**
Hypertension in pregnancy	1	2.38(0.72-7.90)	5.39(2.00-14.71)	7.80(2.65-22.92)
Gestational diabetes	1	¤	0.77(0.15-3.88)	6.16(1.57-24.20)
Mode of delivery	1	3.47(1.62-7.41)	4.07(2.00-8.35)	9.16(4.34-19.31)
Perineal tears ≠	1	¥	2.40(0.76-13.45)	9.33(1.98-56.23)

Adjusted odds ratio (AOR) having accounted for age, parity and HIV. Normal weight used as the reference category. $P < 0.005$

¤ no gestational diabetes was observed in the overweight group.

≠ at least third degree perineal tear.

¥ overweight group did not sustain third degree perineal tears

DISCUSSION

This was the first study done on the effects of obesity of maternal and perinatal outcomes in the Metro West Maternity service area. The current obesity epidemic presents frequent challenges to the obstetric team. From our study, the prevalence of obesity was 40.4%, almost similar to another South African study which had a prevalence of 44% but this was high as compared to the data from the USA that reported a prevalence of 30.5% and that of the UK of 20%.[1,5-8] Prospective studies have shown that higher BMI is associated with older age, and this was also shown by our study. Reasons why there is a high prevalence of obesity could include; reduced levels of physical activity, high calorie intake and social stigma of associating thinness to HIV/AIDS.[3,4]

The association between higher maternal BMI and macrosomia in our study is in keeping with other research.[9-15] Large prospective studies have shown the risk of macrosomic delivery to be between 2.4 to 3.1 times higher in the obese to morbidly obese women compared to normal BMI; and our study showed that the adjusted odds ratios for macrosomia was 4.71 – 9.24 times higher compared to normal BMI. This difference could be explained by the high prevalence of obesity in our study population and also we had a small sample size compared to large population based studies. Recent studies have shown that the proportion of macrosomic babies have increased during the obesity epidemic. Strong correlations have been shown been maternal pre-pregnancy

weight and neonatal weight and percentage of body fat. [22-24] If pre-pregnancy normal BMI is attained, the risk of macrosomia is greatly reduced unless there was excessive weight gain in pregnancy. [27] This finding poses a great challenge in the public health arena as the population has to be sensitized to enter pregnancy with a normal BMI. Macrosomia is a recognized risk factor for developing shoulder dystocia with all its complications and the need for NICU admission. [9-15] Epidemiological studies have shown a continuum from macrosomia to childhood obesity with metabolic complications of hypertension and diabetes and again straining meager health care budgets towards curative care rather than a preventive approach which is cheaper.[25-26]

Our study showed the risk of shoulder dystocia was5.45 times higher in obese compared to normal BMI women which was statistically significant but had very wide confidence intervals. This may be due to the small sample size in our study compared to others in the literature. When BMI $\geq$ 30 was split further into obese and morbidly obese the risk was still higher with morbidly obese but again having very wide confidence intervals. The risk of shoulder dystocia in the morbidly obese was 13.1 compared to normal weight group. This was statistically significant but again with wide confidence intervals.

Other large studies have shown that the odds ratio for NICU admission in the obese group compared to normal weight women is in the range of 1.3 – 1.5, our study showed that the odds ratio was 1.4 but it was not statistically significant.[9-12] This could have been because of the small numbers in the study. However morbidly obese women had 10.75 times odds of being admitted to the NICU and this was statistically significant. The majority of NICU admissions were related to intrapartum events due to difficult delivery associated with shoulder dystocia.

In the literature, there are quoted odd ratios for congenital abnormalities of 1.6 and 3.1 when obese and morbidly obese women respectively are compared to normal weight.[16-17] Our study noted a significant trend of more congenital abnormalities in the obese and morbidly obese, but odds ratio could not be calculated as there were no congenital anomalies in the normal BMI group. Though the incidence of congenital abnormalities was statistically significant in the high BMI group, the absolute numbers were very small but if this is extrapolated on a larger sample size the effect might be strongly significant. The underlying pathophysiology is unknown but it is speculated that there is an altered nutritional environment for fetal development in obese women. [16] Congenital abnormalities occur more frequently in obese women but detection by ultrasonography is poor due to technically difficult scans. [18-19] Although increase in BMI has been associated with increase in congenital abnormalities there has been no consistency in reporting of these abnormalities, since some study centres did not account for all the confounders, the competence of ultrasonographers was different and different BMI categories were used in their assessments which caused data to be heterogenous. [16]

A meta-analysis has shown that obese women are at increased risk of stillbirth. [28] Large prospective studies have shown that the odds ratio for stillbirths is 2.1 when obese women are compared to those with normal BMI. Our study showed an odds ratio of 3.2 when the obese group (BMI ≥30) were compared to normal BMI which was statistically significant with wide confidence intervals. The morbidly obese group had a 9.1 increased chance of experiencing a stillbirth after adjusting for age, parity, hypertension and gestational diabetes. Several reasons have been outlined as to explain the association between obese and high rates of stillbirths. [9-15,28] Higher rates of diabetes

and hypertension occur in obese women compared to the non-obese and these conditions contribute significantly to occurrence of stillbirths. Also, metabolic changes associated with obesity, decreased awareness of fetal movements due to increased abdominal wall adiposity and nocturnal apnoea with transient oxygen desaturation could all contribute towards stillbirths. Even if hypertension and diabetes are adjusted for as confounders stillbirth rates are still high in obese women and a number of studies have shown that the excess of fetal death in obese women is due to fetal growth restriction associated with histological placental dysfunction. [9-15,28] Customized fetal growth charts may be particularly valuable for detecting FGR in obese women. [28]

Population based cohort studies have reported an increased risk of preterm birth in obese women.[21] Women with pre-pregnancy BMI≥ 30kg/m² have a 1.6 increased chance of preterm delivery compared to women with normal BMI. Studies have shown that this increased risk remained significant when women with diabetes, hypertension or preeclampsia were analysed separately. [21] Our study showed that the risk for preterm delivery was 1.7times higher in the obese group which was statistically significant and 2.3 times higher in the morbidly obese group having accounted for the potential confounders. The above finding was echoed by a meta-analysis which showed that the risk of preterm delivery increases with higher grades of obesity. The increase in the risk of preterm delivery has been explained by obesity related medical and antenatal complications that often lead to elective delivery rather that an intrinsic predisposition to spontaneous preterm birth [9-15,21].

Difficult obstetric delivery have been associated with low 5 min Apgar scores [9-12] and our study showed that morbidly obese women had a higher incidence of low 5 minute Apgar scores. It should also be noted that an adverse perinatal event was more likely to occur in the morbidly obese group which poses a challenge in poor resource setting as this group has to be seen in an obstetrician led antenatal care unit. This has cost implications for the patient having to travel to level 2 or tertiary centres and in addition the delivery units having to be equipped with well sized equipment and the ability to deal with a cascade of complications associated with obesity in pregnancy. [9-11]

Prospective Studies have shown that in obese pregnant women there is a 3 times higher risk of developing gestational diabetes. [9-12,29] Our study showed that obese women had 4.7 times chance of developing gestational diabetes but had wide confidence intervals due to the small sample size used. Postulated reasons for high incidence of gestational diabetes has been the increased insulin resistance noted among the obese group. Due to the high prevalence of obesity, prenatal care units in the high income countries screen all obese pregnant women for gestational diabetes[9-12] If this policy is adopted in our poor resource setting then that will have cost implications in the context of limited health care budgets. However, in Metro West maternity service area there is a customized screening policy for gestational diabetes that specifies the following criteria as indications for screening: previous gestational diabetes or 2 or more of the following: obesity, glycosuria, first degree family history of diabetes, previous unexplained stillborn, maternal age ≥40years, previous history of macrosomic delivery. [9-12]

An association between obesity and hypertensive disorders in pregnancy has been consistently reported and maternal weight and BMI are independent risk factors for

preeclampsia and other hypertensive disorders.[31] Our study showed that obese women were 6.1 times more likely to develop hypertension in pregnancy. After accounting for potential confounders, the morbidly obese group was more likely to develop hypertension in pregnancy but had very wide confidence intervals probably due to the small sample size. Fifty seven percent of the women booked after 20 weeks which made it difficult to differentiate gestational hypertension from preeclampsia in the study cohort. Appropriate arm sized blood pressure (BP) cuffs should be available at all antenatal care facilities especially MOUs to get correct BP readings and early referrals made once high BPs are recorded. This is a challenge as some MOUs are not well equipped as evidenced by some folders that did not have BP recordings. Also early antenatal care booking is vital in making the diagnosis of preeclampsia but in low resourced settings, the majority of women have their first antenatal visit late in second trimester. [8,48]

Cohort studies have illustrated that obese women have prolonged labours and this consequently result in an increased frequency of caesarean delivery for labour dystocia.[35] Our study showed that the incidence of caesarean delivery exponentially increased as BMI increased and also the risk of abdominal delivery was higher in the obese compared to the overweight group. However it should also be noted that 85.2% and 74.6% of obese and morbidly obese women respectively achieved a vaginal delivery which still shows that there is a place for vaginal delivery in high BMI groups. Complications of caesarean section arise from anaesthetic, intra-operative and postpartum period and this brings a challenge as the high BMI group is best managed in

a consultant led obstetric unit. This means patients have to travel extra distance from their households for antenatal care.[43-44] To try and cater for the complications from caesarean section, the Metro West region referral criteria advices that obese women with a BMI of > 35 have to be referred for level two care from the MOUs and if they are morbidly obese there should be a consultation with anaesthesiologist for tertiary care referral. Our study did not collect data on anaesthetic details such as time taken to administer spinal anaesthesia, failed spinal and difficult intubation, and also risk of aspiration pneumonia observed in obese women.

Although data are limited, obesity has been associated with a high risk of thromboembolic events but our study showed non-significant difference as we had only two women that developed a thromboembolic event. [43-44] The other reason why we observed such low numbers is that 89.3% of the study cohort had a vaginal delivery and got discharged 6 hours post delivery. Any further complications after discharge were referred to the CHC and that information would not be captured in the maternal obstetric notes. It should also be highlighted that our study showed that all women that were delivered by caesarean section did have thromboprophylaxis provided in one or all of the following ways; thromboembolic deterrent stockings, adequate hydration, early ambulation and use of low molecular weight heparin. Thus, there is a policy in place for thromboprophylaxis in our setting.

Population based cohort studies have shown that the risk of postpartum haemorrhage (PPH) due to uterine atony is increased markedly with increasing BMI. [9-15] Our study

showed the incidence of PPH to be 5 percent which was not significant due to the small numbers. There is a policy in place for the management of PPH that incorporates active management of third stage of labour and any high risk women (fetal macrosomia, prolonged labor, anaemic, assisted vaginal delivery, obese women) do have an oxytocin infusion and/ or misoprostol immediately postpartum.

Some studies have shown a continuum from macrosomia, prolonged labor and / or assisted vaginal delivery, shoulder dystocia to developing third or fourth perineal tears in the obese group. [9-15] Our study showed a statistically significant trend in the occurrence of perineal tears as the BMI increased. Though one cannot predict shoulder dystocia this calls for proper patient selection for vaginal delivery in a scenario where there is obesity, macrosomia and underlying gestational diabetes. Third degree perineal tear repairs of this nature require an experienced surgeon, theatre staff and equipment to cater for obese women, and in addition ward space for post-operative recovery time before discharge.

Limitations of the study

In comparison to other studies, our study had a small sample size and was retrospective in nature so we had no control on the loss to follow ups and missing variables. Second trimester bookings were common which meant that assessment of BMI may not have truly reflected pre-pregnancy BMI; and may have had an impact on the management of hypertension and GDM if diagnosed late in pregnancy. Early pregnancy losses were not captured in this study as they were managed in other facilities. Some participants were excluded because of missing variables like weight, height, and perinatal data; this

reflects poor documentation and a mal-functioning birth registry. Our study may have missed information or other valuable confounding factors like smoking, maternal race, ethnicity and social class. Weight gain in pregnancy was not recorded in the data collection form, although it is known to have an impact on perinatal outcomes. Our study focused on "lower risk" group as we excluded preexisting morbidity so the actual effect of obesity may be greater. Our study was not powered to look at obesity and medical problems in pregnancy (gestational hypertension and GDM) so the medical problems might have been underestimated.

Recommendations

There are implications of the high proportion of obese pregnant women for clinical practice. Women should be encouraged for early booking and also encouraged to enter pregnancy with normal BMI. Our study showed a relationship between high BMI and adverse perinatal outcomes and still echoes what other authors have been advocating for customized guidelines on weight gain in pregnancy in South Africa. Every MOU should offer nutrition consultation to all obese women and a proper weight loss programme should be encouraged during and after pregnancy. Every MOU should be equipped with functioning weighing scales, tape measures and appropriate sized BP cuffs. We also recommend a customized birth cohort registry for our setting that will pick up trends in the obstetric practice like any BMI changes over time in our setting.

CONCLUSION

In our study, the incidence of obesity in pregnancy was high and was associated with adverse perinatal outcomes especially in the morbidly obese women. Obese pregnant women were also associated with adverse maternal outcomes.

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Appendix A: Data collection sheet

FOLDERNUM	
AGE	
HEIGHT	
WEIGHT	
PARA	
DELIVE 1=NVD 2=INSTRUMENT 3=C/S	
PREMEDPROB 1= NON 2=HTN 3=DM 4=OTHER	
NEWMEDPROB 1=NONE 2=HTN 3=DM 3=OTHER	
HIV 1=NEG 2=POS 3=UNK	
GTT 1=NONE 2=ABNORM 3=IGT 4=NORMAL 5=UNKN	
PERINEALTEAR 1= 1ST 2=2ND 3 =3RD, 4 =4TH	
GESTAGEDEL	
PPH 1=YES 2=NO 3= UNK	
THROMPROPH 1=YES 2=N0 3=UNK	
SEPSIS 1=NONE 2=PERINEAL 3=WOUND 4=PELVIC 5=OTHER	
THROMBEMBOLISM 1=NONE 2=DVT 3= PE	
BIRTHWT IN GRAMS	
APGAR5MIN	
SHOULDERDYST 1=NO 2=YES 3=UNK	
CONGENABNOR 1=NONE 2=NTD 3=CARDIAC 4=GIT 5=OTHER	
PERINDEATH 1=ALIVE 2=SB 3=ENND	
MOMICU 1=NO 2=YES 3=UNK	
MOMHOSPSTAY (DAYS)	
BABYICU 1=NO 2=YES 3=UNK	

STUDYNUM

Appendix B. UCT research ethics approval letter

HREC Ref 463/2012 – 18Oct2012

UNIVERSITY OF CAPE TOWN

Faculty of Health Sciences
Human Research Ethics Committee
Room E52-24 Groote Schuur Hospital Old Main Building
Observatory 7925
Telephone [021] 406 6338 • **Facsimile** [021] 406 6411
e-mail: shuretta.thomas@uct.ac.za

18 October 2012

HREC REF: 463/2012

Dr T Horak
c/o Prof S Fawcus
Obstetrics & Gynaecology
H-Floor, OMB

Dear Dr Horak

PROJECT TITLE: ADVERSE PERINATAL EVENTS OBSERVED IN OBESE PREGNANT WOMEN IN THE METRO WEST REGION

Thank you for responding to the issues raised by the Faculty of Health Sciences Human Research Ethics Committee in your letter dated 15th October 2012.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year till the 30th October 2013

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/research/humanethics/forms)

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the HREC. REF in all your correspondence.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN ETHICS
Federal Wide Assurance Number: FWA00001637.

Institutional Review Board (IRB) number: IRB00001938
This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

s.thomas

Appendix C. Department of Health Western Cape approval letter

Western Cape Government
Health

STRATEGY & HEALTH SUPPORT
healthres@pgwc.gov.za
tel: +27 21 483 9907: fax: +27 21 483 9895
1st Floor, Norton Rose House,. 8 Riebeek Street, Cape Town, 8001
www.capegateway.gov.za)

REFERENCE: RP 150/2012
ENQUIRIES: Ms C Roderick

UNIT 13 ANFIELD VILLAGE
FOREST DRIVE EXTENSION

PINELANDS, 7405

CAPETOWN

For attention: DR LUIS A. GADAMA

Re: ADVERSE PERINATAL EVENTS OBSERVED IN OBESE PREGNANT WOMEN IN THE METRO WEST REGION

Thank you for submitting your proposal to undertake the above-mentioned study. We are pleased to inform you that the department has granted you approval for your research.

Please contact the following people to assist you with any further enquiries.

Mowbray Maternity **Prof S Fawcus** **(021) 659 5578**

Kindly ensure that the following are adhered to:

1. Arrangements can be made with managers, providing that normal activities at requested facilities are not interrupted.
2. Researchers, in accessing provincial health facilities, are expressing consent to provide the department with an electronic copy of the final report within six months of completion of research. This can be submitted to the provincial Research Co-ordinator (healthres@pgwc.gov.za).
3. The reference number above should be quoted in all future correspondence.

Yours sincerely

DR NT Naledi
DIRECTOR: HEALTH IMPACT ASSESSMENT
DATE: 30 / 11 / 2012

CC **DR K GRAMMER** **DIRECTOR: SOUTHERN WESTERN**

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