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Does high body mass index affect the unplanned cesarean section rate and its indications in healthy nulliparous women without other risk factors?

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Thesis

DOES HIGH BODY MASS INDEX AFFECT THE UNPLANNED CESAREAN SECTION RATE AND ITS INDICATIONS IN HEALTHY NULLIPAROUS WOMEN WITHOUT OTHER RISK FACTORS?

by

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DEDICATION

This research is lovingly dedicated to my wonderful children (Malak, Laith, and Lujain), my husband Haithm, my supportive family; and, my beloved city Benghazi.

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ABSTRACT

Objectives: The effect of body mass index **(**BMI) was assessed on unplanned cesarean section (CS) rate and its indications among healthy, nulliparous women without other risk factors for CS.

Method: A cross sectional study was performed on 1649 healthy, nulliparous women at term who were admitted in spontaneous labor and delivered at Boston Medical Center between Jan 1st 2008 and Dec 31st 2012. The demographics and outcomes were compared by using a logistic regression analyses.

Result: There were no statistically significant differences in unplanned CS rates between the three BMI groups (19% in normal weight, 24% in overweight, and 21% in obese women, p=0.1). Compared with normal weight women the crude odds ratio for overweight women was 1.34 (95%CI 1.03-1.76) and for obese women 1.04 (95%CI 0.84-1.54). A multivariate logistic regression analysis was used to adjust for maternal age, birth weight, race and augmentation of labor. The adjusted ORs were 1.073 (95%CI 0.781-1.473) for obese and 1.291 (95%CI 0.978-1.705) for overweight women. Obese women had a higher rate of CS for non-reassuring fetal status (56%, p= 0.01) compared to overweight (46.5%) and normal weight women (37%).

Conclusion: high maternal BMI per se does not appear to be an independent risk factor for unplanned CS in healthy nulliparous women presenting at term with a singleton pregnancy in spontaneous labor.

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LIST OF ABBREVIATIONS

ACOG	American Congress of Obstetricians and Gynecologists
BMC	Boston Medical Center
BMI	Body Mass Index
CDC	Centers of Disease Control and Prevention
CDW	Clinical Data Warehouse
CS	Cesarean Section
CTG	Cardiotocography
FHR	Fetal Heart Rate
IRB	Institutional Review Board
MR	Medical Records
RCOG	Royal College of Obstetrics and Gynecology
WHO	World Health Organization

INTRODUCTION

I. <u>OBESITY</u>

Both overweight and obesity are defined as "abnormal or excessive fat accumulation that may impair health."[1] The World Health Organization (WHO) uses the body mass index (BMI), "the weight in kilograms divided by the square of the height in meters (kg/m^2),"[2] to classify body weight into four categories: underweight (less than kg/m^2), normal weight (18.50–24.99 kg/m^2), overweight (25–29.99 kg/m^2), and obese (greater than 30 kg/m^2).[2] Obesity can be further categorized into class I obese (BMI 30–34.9 kg/m^2), class II obese (BMI 35–39.9 kg/m^2), and class III obese (BMI ≥40 kg/m^2).[1]

I.1. OBESITY INCIDENCE IN WOMEN OF CHILDBEARING AGE

Over the past several years, overweight and obesity have developed into a public health problem, particularly among American women of reproductive age. In fact, in 2010, 55.8% of American women of childbearing age were classified as having an elevated BMI.[3] Alarmingly, the rate of obesity is projected to reach 42% by 2030.[4] Moreover, approximately half of pregnant women are either overweight or obese immediately before pregnancy (25% overweight, 24.1% obese); the rate is the highest in African American and Hispanic women.[5,6]

I.2. OBESITY COMPLICATIONS IN WOMEN

Obesity has contributed to the increase in the incidence of diabetes mellitus, hypertension, and heart diseases.[1] In young women, obesity is also associated with several reproductive complications before and during pregnancy, contributing to infertility, pre-eclampsia, gestational diabetes, an increase in the rate of induction of labor, cesarean section (CS), and anesthesia complications.[7,8,9,10] Numerous studies have found that women with high BMI are also at higher risk for post CS complications, such as postpartum hemorrhage, wound infection, and delayed wound healing.[11] In addition, high maternal BMI is associated with increased risk of adverse fetal outcomes such as congenital anomalies, intrauterine fetal death, preterm labor, and neonatal admission to intensive care unit.[8,12]

I.3. OBESITY AND CESAREAN SECTION

An association between obesity and a higher risk of cesarean section (CS) has been noted for a number of years by several professional societies, including the American College of Obstetricians and Gynecologists (ACOG).[13] This association may explain in part the high CS rates observed in the US and other industrialized countries where obesity rates, particularly among women and minority populations, have reached epidemic proportions. In 2008, a meta-analysis of 49 cohort studies demonstrated an increased unplanned CS, but not elective CS rates in obese women. However, these studies did not address the parity issue.[14] Furthermore, in 2011 Dodd et al. found that obesity is a double risk factor for both unplanned and elective CS, compared to normal weight women; postulating that a higher rate of labor induction may be the reason behind the increased CS risk in obese women.[15] This was confirmed in another study that demonstrated obesity to be an independent risk factor for CS, although obese women with high risk pregnancies were not excluded.[16] In 2009, a meta-analysis of cohort studies showed that the crude pooled odd ratios of having a unplanned CS for nulliparous overweight and obese women was 1.64 (1.55, 1.73), and 2.23 (2.07, 2.42), respectively, compared to a control group of normal weight nulliparous women.[17] The strength of this meta-analysis was that it included studies that either enrolled nulliparous women only or had a stratified analysis to eliminate the influence of parity on CS rates. Further, diabetic and hypertensive women were excluded, eliminating the potential confounding effect of these factors on CS risk.[17] Yet, there is always the possibility that other potentially unknown confounding risk factors may have been overlooked such as height.

Several mechanisms have been suggested to explain the association between obesity and high CS rates. Pregnant obese women are more likely to have macrosomic babies (>4000 grams at term), and that was found in a 2008 study to be an important contributor to the high CS rates in this group of women. Macrosomia is also associated with higher rates of malpresentation and postdates pregnancy, which in turn are associated with higher intervention rates to expedite delivery. Labor inductions at or near term may also be necessary for medical complications, e.g. gestational diabetes and hypertensive disorders which occur frequently in pregnant obese women. It is well known that labor induction with an unripe cervix is associated with a significantly higher risk of CS compared to spontaneous labor, and that may be an important contributor to the high unplanned CS rates observed in obese women.

Regardless whether labor is spontaneous or induced one of the most common indications for unplanned CS is failure to progress. While cephalopelvic disproportion due to macrosomia and malpresentation is an obvious cause of failed progress, a number of studies have also shown a tendency towards less effective uterine contractility in laboring obese women,[18,19,20,21] and also in laboring diabetic women.[22] This could result in dysfunctional labor, failure of timely progress and increased CS risk. It is noteworthy that a relatively higher level of cholesterol had been observed in the uterine myometrium of obese women, a finding that was implicated in the genesis of ineffective uterine contractions, dysfunctional labor and delays in the first and second stages of labor.[18] Labor augmentation with oxytocin is often required in such situations and that could lead to a higher CS rate.[23] A 2010 study however, cast some doubt on this theory, finding no association between BMI and myometrial contractility in vitro.[24] It is possible that the discrepant findings between studies on uterine contractility in obese women may be due to the confounding effect of diabetes and other metabolic factors that have been controlled for in some studies but not in others.

Another common indication for unplanned CS is the persistence of a non-reassuring fetal heart tone (NRFHT) during labor. Of the various indications for CS, this is perhaps the one that continues to carry with it a significant degree of subjectivity, despite ongoing efforts by ACOG to standardize definitions and interpretations of fetal tracings. NRFHT due to placental insufficiency is often encountered in high-risk pregnancies (e.g. diabetes and hypertension). NRFHT is also encountered frequently during labor inductions and augmentations with prostaglandins and oxytocin. Given that all these risk factors frequently coexist in obese labors, it is not surprising that NRFHT remains a major indication for unplanned CS in obese women. Furthermore, continuous electronic fetal heart monitoring by cardiotocography (CTG) can be technically challenging due to equipment and nursing limitations imposed by abdominal fat in obese women. This can theoretically lead to an early decision to abandon further monitoring and proceed with a CS, thereby contributing to the higher CS rates.

It should be noted finally that considerable variability exists in CS rates between various countries, between regions in the same country and even between different facilities in the same region or city.[25] CS risk may indeed be influenced by the hospital chosen for delivery, as concluded in a study by the Harvard School of Public Health (HSPH).[26] This may be a reflection of the patient mix, the provider mix and the prevailing attitudes, practices and policies regarding the conduct of labor and delivery at any particular facility. Among 42 Massachusetts hospitals for example, the primary CS rates ranged between 14% and 38.3%.[26] Adjusting for several maternal risk factors did not completely eliminate the hospital variation in the CS rates although no adjustments were made for maternal BMI.[26] As to obstetrical provider mix (e.g. obstetrician vs. midwife), one study noted no influence on CS risk,[27] while another found a wide range of CS rates (0-44%) among delivering obstetricians![28] At Boston Medical Center (BMC) the reported primary CS rate since 2009 has been at 19.7%. This admittedly exceeds the optimum 15% rate set forth by the World Health Organization (WHO),[29] but remains one of the lowest rates in the state of Massachusetts.[30] Thus, for the purposes of this study, BMC would be an ideal facility to investigate the true nature of the association between obesity and the risk of unplanned CS, trying to control for as many confounders as possible.

STUDY RATIONALE

Previous studies addressed the fact that overweight and obesity are risk factors for increasing the CS rate (refer to Introduction section I.1.3).[14,15,17] Therefore, it is important to detect the actual relationship between BMI and CS rate by excluding all known co-morbidities and risk factors for increasing the CS rate (refer to method section).

PURPOSE

The aim of the study is to verify that obesity is an independent risk factor for unplanned CS. This aim will be assessed by comparing the results among healthy patients with normal BMI versus overweight and obese women.

STUDY QUESTION

Does high body mass index affect the unplanned CS rate and its indications in healthy nulliparous women without other risk factors in spontaneous labor at Boston Medical Center?

OBJECTIVES

Primary:

- Estimate the prevalence of CS among obese, overweight and normal weight BMI categories in healthy nulliparous women who had a spontaneous labor.

Secondary:

- To determine the impact of BMI on the indications for unplanned CS in this study sample.

The predictive variable of this study will be the BMI categorized according to the WHO and CDC (refer to introduction and method section). The outcome variables will include the prevalence rate of unplanned CS and the percentage of each indication for unplanned CS in each group. The indications will include non- reassuring fetal status, failure to progress, malpresentation, cord prolapse, and placental abruption.

METHODS

STUDY DESIGN AND THE TYPE OF DATA COLLECTED:

This was a cross-sectional study conducted at Boston Medical Center (BMC). De- identifiable data from 2008 to 2012 was gathered from the BMC Clinical Data Warehouse (CDW) "a repository of historical data organized for reporting and analysis".[31] The main information collected included:

1. Patient demographics:
    - Age by year at time of delivery: The Royal College of Obstetrics and Gynecology (RCOG) specify that patients with advanced maternal age are those age 35 and older.[32] Thus, the age in this study was divided into (<35 Yrs. and ≥ 35 Yrs.).
    - Race: Was divided into five main groups including White, Black, Hispanic, Asian, and Others (included low frequency race, e.g. Middle East, Hawaiian and Native Indian).
    - Maternal height in inches.
    - Gestational age: The term gestational age was defined by the ACOG as fetal age of ≥ 37 weeks gestation and was divided it into 6 categories (37, 38, 39, 40, 41, and 42 Weeks) .[33]
    - Birth weight: Categorized into three categories including (<2500g), (2500-3999g), and (>4000g). According to ACOG criteria, infants who weighed between 2500-3999g at birth were deemed of normal birth weight, and this

class has a low risk for birth injury or health problems compared with the other two categories.[34]

- Use of epidural anesthesia during the first stage of labor.
- Augmentation of labor using oxytocin.

2. BMI: was categorized into normal, overweight, and obese. This categorization includes both the interpreted BMI according to WHO for adults aged ≥ 21-years-old (refer to introduction section I.1.1) and the Centers of Disease Control and Prevention (CDC) interpretation for teens (18 to 20 years old).

   The (CDC) determined that BMI calculations for children and adolescents (up to 20 years old) differ from adults based on the child's or adolescent's age and sex as age and sex affect the amount of body fat.[35] Thus, their BMI is calculated using the same adults formula but the result from this formula is interpreted by using the CDC-BMI-for-age percentiles chart (Figure 1) and not by using the adult categories.[35] BMI for age ≤ 20 years is classified into four categories: underweight (≤ 5^{th} percentile); normal weight (5^{th} to less than 85^{th} percentile); overweight (85^{th} to less than 95^{th} percentile); and, obese (≥ 95^{th} percentile).[35] For example, a BMI of 23 kg/m^2 for a 19-year-old girl is considered overweight, but for a 10-year-old it is interpreted as obese.[35]

3. Primary Indication for CS: Information for the indication for unplanned CS was collected from the Citrix Prenatal Nurse database where the indications were divided into primary (one) and secondary (one to multiple) indications. This study calculated the percentage of primary indications because they were the main

cause for the CS (there was only one primary indication for each patient).

Approval of the Institutional Review Board (IRB) of Boston University was obtained before conducting the study.

STUDY POPULATION:

The inclusion and exclusion criteria were chosen to create a cohort of parturients whereby women with known non-BMI related risk factors for CS were eliminated. By eliminating potential confounders of risk, a better understanding for the effect of BMI on CS rate could be estimated.

1. INCLUSION CRITERIA:

a. Study period from 2008 to 2012 (5 years).
b. BMI available at first prenatal visit either during the first or early second trimester (refer to discussion section I.1.).
c. Age ≥ 18 years old.
d. Nulliparity (to eliminate those with prior CS attempting a trial of labor, a confounder of risk).
e. Spontaneous labor (to avoid induced labor, an important confounder of risk)
f. Singleton fetus (to eliminate multiple pregnancies).
g. Term pregnancy ≥ 37 gestational weeks. (to help eliminate multiple

confounders of CS risk commonly present in women with preterm labor) These confounders, e.g. uterine fibroids, smoking, family history, physical and emotional abuse are otherwise undetectable by the use of anonymous CDW data.[36]

2. EXCLUSION CRITERIA:

a. Medical conditions: Those considered risk factors for CS including diabetes mellitus, gestational diabetes, pre-eclampsia, hypertension, herpes simplex, heart, and renal diseases were excluded. Women with anemia, well-controlled thyroid disorders, asthma and other medical conditions with no known impact on CS rate were not excluded.[37]
b. Chorioamionitis: This bacterial infection of the fetal membranes is often associated with non-reassuring fetal status in labor and an increased risk of CS.[38] Women with this diagnosis were thus excluded.
c. BMI < 18.50 kg/m^2 (underweight). Underweight patients were excluded because the focus of this study was on normal to high BMI.
d. Elective scheduled CS, performed before the onset of labor.

SAMPLE SIZE CALCULATION:

Sample size was calculated using SAS (Version 9.3, SAS Institute, Inc., Cary, NC) and it was based on a study carried by O'Dwyer, et al., 2011.[39] Sample size was calculated using N-Query Advisor for unequal sample sizes for the two groups with ratio n2/n1=1.3. A two group chi square test with a 0.05 two-sided significance level had the 80% power to detect the difference between a normal weight group proportion, p_1, of 1.150 and obese group proportion, p_2, of 0.200 (odds ratio of 1.417) when the sample sizes were 798 and 1062, respectively (a total sample size of 1860).

Two group c^2 test of equal proportions (odds ratio = 1) (unequal n's)

Test significance level, a	0.050
1 or 2 sided test	2
Group 1 proportion, p_1	0.150
Group 2 proportion, p_2	0.200
Odds ratio, y = p_2 (1 - p_1) / [p_1 (1 - p_2)]	1.417
Power (%)	80
n_1	798
n_2	1062
Ratio: n_2 / n_1	1.330
N = n_1 + n_2	1860

STATISTICAL ANALYSIS:

Data were described statistically by the use of mean ± Standard deviation (SD), percentages, and number of cases when appropriate. Chi-square or fisher exact test were performed to analyze differences in unplanned CS rates as well as for group comparisons for categorical data when appropriate, while ANOVA was used for comparison of continuous data. A p-value less than 0.05 were considered statistically significant. All the calculations were done using SAS (Version 9.3, SAS Institute, Inc., Cary, NC). Logistic regression was used to adjust for potential confounders by reporting odds ratio and 95% Wald Confidence interval. In addition, trend over years (2008–2012) by unplanned CS rates was determined (refer to result Section).

RESULTS

A total of 12,926 deliveries were found, of these 4625 were nulliparous. The medical records (MR) of 1951 parturient who met study inclusion /exclusion criteria were reviewed. Of those, 1649 (84%) had complete information allowing for the calculation of BMI and 352 (21%) of them had the unplanned CS (Figure 1).

The distribution of maternal and fetal characteristics is presented in Table 1. The demographic characteristics of women in the three BMI groups differed from each other. Both overweight and obese women tended to have a higher percentage of women over 35 years old (p=0.04), a higher percentage of African American and Hispanic women (p=0.0001), and a higher percentage of macrocosmic deliveries (birth weight > 4000g) (p=0.003) compared to normal weight women. In addition, to have their labor augmented (p=0.003). However, gestational age (p=0.1), height (p=0.45) and the use of epidural analgesia (p=0.8) were not statistically different among the three BMI groups.

Table 1: Demographic characteristics of nulliparous healthy women without additional risk factors in spontaneous labor, N=1649

Characteristics	Normal (n= 742)	Overweight (n= 523)	Obese (n= 384)	P-value
Age[1] (Yrs.), n (%)				**0.04***
< 35 Yrs.	700 (94%)	481 (92%)	347 (90%)	
≥ 35 Yrs.	42 (6%)	42 (8%)	37 (10%)	
Race[1], n (%)				**<0.0001**
Black	315 (43%)	266 (51%)	215 (56%)	
Asian	66 (9%)	19 (4%)	6 (2%)	
Hispan	144 (19%)	121 (23%)	77 (20%)	

White	148 (20%)	76 (15%)	47 (12%)	
Others	69 (9%)	41 (7%)	39 (10%)	
Height[2] (inch), mean(SD)	63.6 (2.9)	63.58 (2.9)	63.4 (3.03)	0.45
Gestational age[1], n (%)				0.1
37 weeks	58 (7.82%)	27 (5%)	21 (5.5%)	
38 weeks	113 (15%)	85 (16%)	50 (13%)	
39 weeks	325 (44%)	222 (42%)	175 (46%)	
40 weeks	189 (25%)	137 (26%)	90 (23%)	
41 weeks	57 (8%)	52 (10%)	48 (13%)	
Birth weight[1](g), n (%)				**0.003***
<2500 g	24 (3%)	18 (3%)	5 (1%)	
2500-3999 g	688 (93%)	465 (89%)	346 (90%)	
≥4000 g	30 (4%)	40 (8%)	33 (9%)	
Epidural analgesia[1], n (%)	447 (60%)	320 (61%)	237 (62%)	0.8
Augmentation of labor[1], n (%)	207 (28%)	186 (36%)	137 (36%)	**0.003**

[1] Chi Square test
[2] ANOVA
* Significant P-value (< 0.05)

The distribution of total and CS deliveries stratified by three BMI categories (Normal, Overweight, and Obese) is shown in Table 2. For the primary outcome of the study (i.e., unplanned CS rates), there were no statistically significant differences between the three BMI groups, although the CS rate in overweight women was inexplicably 3% higher than that in obese women.

Table 2: Rate for unplanned CS among healthy nulliparous women, N=1649

	Normal (n=742)	overweight (n=523)	Obese (n=384)	P-value
Rate of unplanned CS [1], n (%)	143 (19%)	127 (24%)	82(21%)	0.1

[1] Chi Square test

Data analysis using crude and adjusted logistic regression models indicated a weak association between maternal BMI and risk of unplanned CS. A significant increase in unplanned CS was found in the overweight group compared to the normal BMI group (OR = 1.3, p=0.03), however the difference in unplanned CS between the obese and normal groups was not significant (OR = 1.1, p=0.41). After adjusting for maternal age, low birth weight, labor augmentation and race, the results were mostly similar; with the difference between overweight and normal weight groups remaining only borderline significant (p=0.07). No significant associations were found between CS rates and either low birth weight or race, however, maternal age was associated with unplanned CS (P=0.002), and augmentation of labor was also associated with CS rate with borderline significance. In a univariate analysis of the data, all covariates were associated with the BMI but only advanced maternal age was associated with the outcome. Women with advanced maternal age had a slightly but significantly higher odds of unplanned CS compared to younger women (Table 3).

Table 3: Adjusted risk of unplanned CS by selection variables

Effect	Odd ratio point estimate	95% Wald confidence limits [a, b]	P-Value
Obese vs. Normal	1.073	(0.781-1.473)	0.6
Overweight vs. Normal	1.291	(0.978-1.705)	0.07
Advanced age	1.049	(1.026-1.072)	**0.002***
birth weight	1.454	(0.753-2.807)	0.25
Augmentation of labor	1.272	(0.99-1.635)	0.07
Race:			0.96
Black vs. others	1.087	(0.821-1.439)	
White vs. others	0.914	(0.627-1.331)	

[a] 95% Wald Confidence Interval.
[b] OR reported are adjusted for maternal age, low birth weight, augmentation of labor and race.
*Significant result (p≤0.05)

As to the secondary outcomes of the study, Table 4 shows the indications for CS in each BMI category and their rate. This study calculated the percentage of primary indications because they were the main cause for the CS (there was only one primary indication for each patient). Obese women had a significantly higher proportion of CS for non-reassuring fetal status (56%, p=0.01). Normal BMI women had a borderline significant higher proportion of CS for malpresentation (20.5%, p=0.06). Finally, there was no trend over years (2008-2012) by unplanned CS rates (p=0.71) among healthy nulliparous women with no additional risk factors.

Table 4: Indications for unplanned CS, N=352

	Normal (n=	Overweight(n=127)	Obese (n=82	P-value
1. Non-reassuring fetal status[1], n (%)	53 (37%)	59 (46.5%)	46(56%)	**0.01***
2. Failure to progress[1], n (%)	58 (40%)	49 (38%)	26 (32%)	0.7
3. Malpresentation[1], n (%)	29 (20.5%)	16 (13%)	8 (10%)	0.06
4. Placenta abruption[1], n (%)	2 (1.5%)	3 (2.5%)	2 (2%)	0.8
5. Cord prolapse[1], n (%)	1 (1%)	0	0	0.4

* Significant P-value (< 0.05)
[1] Chi Square test or Fisher Exact test

In an attempt to explore the unexpected findings of a higher CS rate among overweight women compared to obese women (Table 2), the demographic characteristics of all women who delivered by unplanned CS, were stratified by BMI category and compared (Table 5). Except for a statistically significant overrepresentation of Black women in the obese BMI category, there was no significant difference in demographics between the three BMI groups.

Table 5: Demographic characteristics of those women who had unplanned CS (n=352)

	Normal N=143	Overweight N=127	Obese N=82	P-value
Age [1](Yrs.), n (%):				0.31
< 35 Yrs.	131 (92%)	109 (86%)	73 (89%)	
≥ 35 Yrs.	12 (8%)	18 (14%)	9 (11%)	
Race [1], n (%):				**0.007***
Black	52 (36%)	70 (55%)	49 (60%)	
Asian	16 (11%)	9 (7%)	2 (2%)	
Hispanic	30 (21%)	24 (19%)	14 (17%)	
White	31 (22%)	15 (12%)	8 (10%)	
Others	14 (10%)	9 (7%)	9 (11%)	
Height (inches) [2], mean (SD)	63.05 (2.7)	62.9 (2.7)	62.8 (2.2)	0.73
Gestational age[2], mean (SD)	39.18 (1.13)	39.38 (1.08)	39.4 (1.17)	0.22
Birth weight [1](g), n (%)				0.6
<2500 g	5 (3.5%)	6 (5%)	2 (2%)	
2500-3999 g	127 (89%)	104 (82%)	70 (85%)	
≥4000 g	11 (8%)	17 (13%)	10 (12%)	
Epidural analgesia[1], n (%)	83 (58%)	71 (56%)	44 (54%)	0.8
Augmentation of labor[1], n (%)	53 (37%)	45 (35%)	29 (35%)	0.9

[1] Chi Square test
[2] ANOVA test
* Significant P-value (< 0.05)

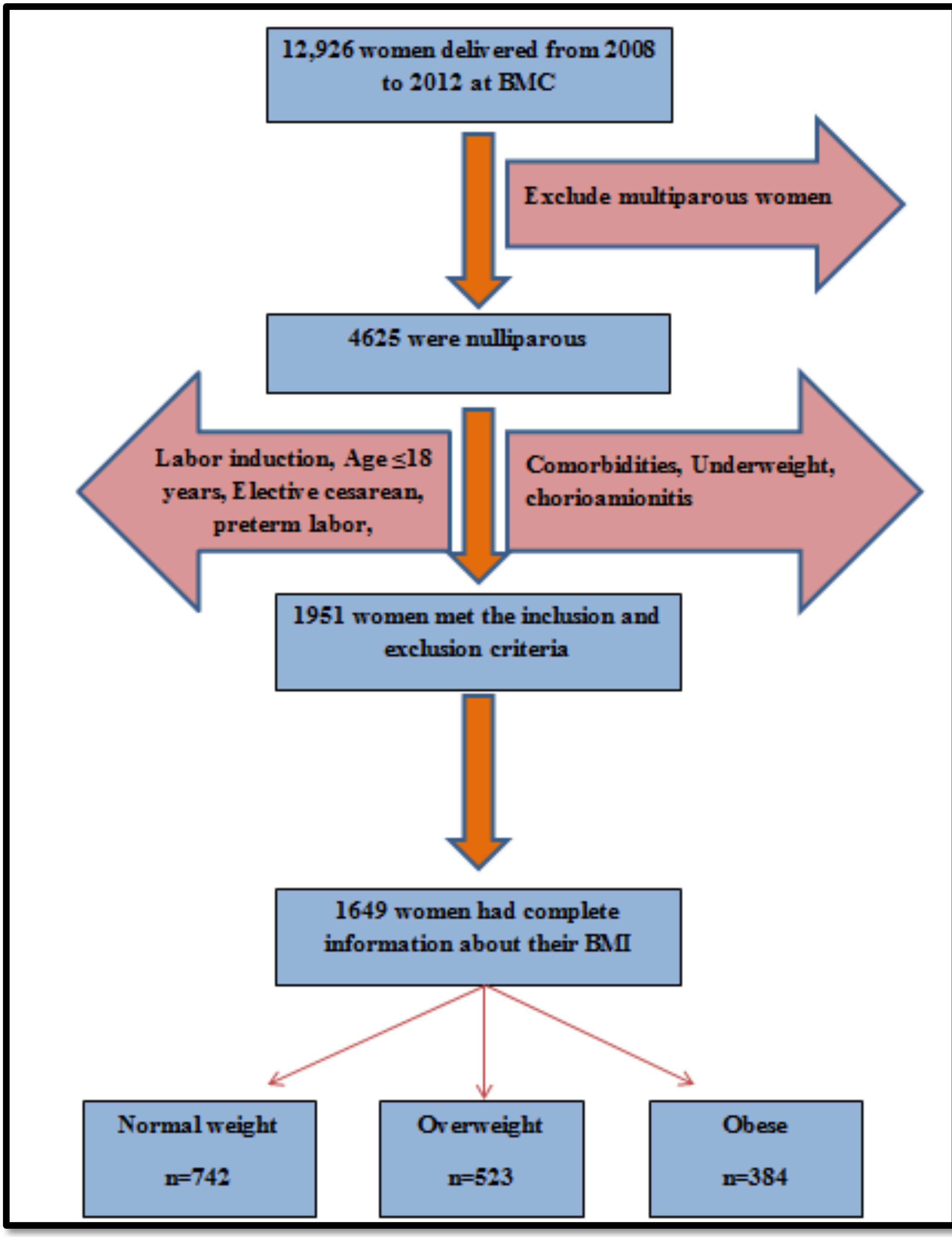

Figure 1: Study cohort

DISCUSSION

As far as the primary purpose of this study, the results indicate that overweight and obese women with no other co-morbidities or risk factors have the same risk for unplanned CS as women of normal weight. This result is in agreement with a 1978 British study, a 1999 Scandinavian study, a 2011 Australian study (after adjustment for induction of labor), and another study performed in 1980,[40,41,42] but contradicts other studies.[14,15,17] These prior studies either did not control for parity or did not exclude other confounders of CS risk. A more recent article, published in 2014 (while the current study was already in progress), is similar to the current study. It included 19,000 healthy nulliparous women without other co-morbidities and risk factors and reported a very small increased risk of obstetrical interventions (composite of CS, augmentation of labor, and instrumental delivery) in the overweight and obese group (adjusted RR for overweight 1.04, CI 95% 1.01-1.11; adjusted RR for obese 1.12, CI 95% 1.05-1.18).[43]

Yet none of the previous studies have adjusted for height despite the fact that a short stature is a risk factor for CS.[44]

This study's findings may reflect the stringent methodology whereby exclusion of almost all known risk factors for unplanned CS allowed for a more precise un-confounded determination of the true impact of BMI on primary CS rate, which turned out to be minimal. However, it is possible that service policies and obstetrical practices at BMC promoting the lowest CS rate in the region may have made it difficult to detect differences in those rates between BMI groups (refer to introduction section I.1.3). It is also possible that the trend towards a slightly higher CS rates in overweight and obese women may have reached statistical significance had the sample size been slightly larger. As to the 3% higher CS rate in overweight compared with obese women, it remains inexplicable despite the demographic analysis of Table 5.

In comparison to normal weight women, obese women in this study tended to have higher percentage of older age women, more African American, and have more augmentation of labor, findings that confirm those of prior studies. These prior studies have also found obesity to be associated with less effective uterine contractility, and a prolonged first stage of labor.[45,46] This may explain the higher frequency of labor augmentation in obese women in this study.

As far as secondary outcomes, the higher prevalence of non-reassuring fetal status as an indication for CS among obese women is in agreement with findings from earlier studies. The main cause stated in one previous study is the high frequency of augmentation of labor. However, in the current study, there was no significant difference in the augmentation of labor in obese women who had an unplanned CS (Table 5) compared with overweight and normal weight women, and this could suggest that it is not the only cause for the non-reassuring fetal status that occurred. It would be useful to determine the fetal outcome of those women who had an unplanned CS for non-reassuring fetal status, but using de-identifiable data did not allow for collecting this information.

An additional finding in the current study was the high frequency of unplanned CS for malpresentation (borderline significance) in the normal group despite opposite results in previous studies. Short stature and big babies could lead to a higher rate of malpresentation. Therefore, an analysis to detect a difference in the height and birth weight among the three groups who had CS was performed, but no differences were found among them, suggesting the possibility of rolling out that explanation. Although, a previous study showed that malpresentation is more common in women with White race,[47] and this was the same result in the current study where women of normal weight who had higher percentage of malpresentation were more white compared with overweight and obese, but the cause for the high percentage of malpresentation in this subgroup is unknown.

A previous study found that during labor high BMI women are managed differently than normal weight women and this contributed to the increase in the CS rate in these women.[48] Obstetricians should not be influenced by existing data on the relation between high BMI and CS rates, especially if obese women present at term and in spontaneous labor. Therefore, the clinical implication of this study is that its result will help reduce the effect of maternal weight on obstetricians and midwifes when they are handling these deliveries and it helps in reducing the obstetricians' perception that obese women are unable to deliver vaginally. Therefore, obstetricians and midwifes should allow women with high BMI and who do not suffer from other co-morbidities to experience the adequate trial of normal labor and without induction. The results of this study show the low risk of CS in healthy overweight and obese women, although, it did not look for other possible complications, such as instrumental delivery, post-partum hemorrhage, and other possible CS complications. Therefore, obstetricians and nurses should allow these women to experience a normal vaginal delivery, albeit with more caution in terms of other possible complications that could occur at a higher rate in this group of women.

I. LIMITATIONS

Several limitations of this study should be acknowledged. Firstly, the study design was cross-sectional and the findings were based on de-identifiable, retrospective data taken from the CDW, thereby raising the probability of missed information (26% of the study population had missed information related to their BMI). However, there is no reason to think that the majority of these women with missed information are specifically from one BMI group.

Secondly, the best baseline information about women's weight is before pregnancy. In this study, the weight used to calculate women's BMI was the weight measured at their first booking date (in either the first or second trimester) as this weight is still close to the pre-pregnancy weight. In addition, there was a uniform distribution of the first booking dates among the three BMI groups, thereby minimizing the selection bias. Perhaps a more valid concern however is that many women excluded for missing first and second trimester data may have received inadequate prenatal care, a potential marker of increased CS risk. This could have contributed to a falsely lowered CS rate in all BMI categories.

Thirdly, the sample size of this study (n=1649 women) accounts for a small percentage from the total deliveries at BMC within the five-year timeframe (n=12,926 women total deliveries, and n=4625 nulliparous women). Thus, most deliveries were multiparous, and a high rate of the induction of labor and co-morbidities existed among other nulliparous women. However, this does not affect the results of the current study because the aim of the study could only be achieved by evaluating the outcome in a sample pure from any co-morbidities and risk factors for unplanned CS.

Fourthly, the findings of this study can be generalized to American nulliparous pregnant women but not multiparous women.

Fifthly, despite controlling for known confounders such as age, race, gestational age, epidural analgesia, augmentation of labor, height, and birth weight; the existence of uncontrolled confounders e.g. waist circumference is still possible. According to the National Heart, Lung, and Blood Institute guidelines, both BMI and waist circumference must be measured in order to determine the probability of an obese or overweight person developing a health problem.[49]Combining BMI with waist circumference is a better predictor for obesity related morbidity in women, compared to BMI only.[49,50] It is noteworthy to know that all the previously noted studies that conducted research on the effect of BMI on CS rate did not control or include the waist circumference in their analysis.

Sixthly, measurement bias is a possibility due to the use of different weight scales or self-reported weight and height. Self-reported weight is usually less than actual or measured weights and that could result in an underestimation of obese and overweight women and therefore an overestimation of CS rates. This bias would probably shift the findings toward the null hypothesis because it will be evenly distributed among the three groups.

Finally, this study carries the risk of type II error due to its low power, which leads to an inability to detect the possible effect of obesity on the un-planned CS rate. In addition, the sample size for obese women was small (n=82 women), which did not allow for more stratification of the obese group (class I, II, and III obesity) to know the difference between these classes.

II. STRENGTHS

One of the strengths of this study is the use of the CDC's BMI-for-age chart for parturients between 18 and 20 years of age, especially that teens composed approximately (19%) of the study sample. This had not been reported in any prior studies on the subject. According to the CDC, it is incorrect to interpret teens' BMI using the BMI categories for adults.[35] Therefore, the use of the CDC's BMI-for-age-chart and percentile in the current study allowed teen parturients to be allocated appropriately to the BMI category to which they belong; this should have helped reduce any overestimation or underestimation of the rate of CS among the three BMI groups.

Second, the study sample was homogeneous (nulliparous in spontaneous labor), and the women did not have any known co-morbidities or risk factors associated with higher CS rates. This allowed for a better understanding of the effect of BMI on the unplanned CS rate.

III. FUTURE DIRECTIONS

Future prospective and adequately powered studies are needed to confirm and expand on the results of the current study. It would be useful as well to conduct similar studies at other hospitals in the city that have higher intervention and CS rate than

BMC. A similar study at hospitals with a high CS rate and larger obstetric volumes might also allow stratification of obese primary CS rates by time of delivery (e.g., morning, evening, and night shifts). This might help identify any extraneous, systemic, and non-obstetric factors influencing those rates. While BMI is an acceptable and widely used measure of adiposity, it does not necessarily differentiate between central and peripheral adiposity. Since central adiposity is more of a marker for metabolic dysfunction, prospective studies on obese CS rates controlling for waist/hip ratios may prove quite revealing. This would require obtaining these measurements routinely at the first prenatal visit, which is not a common practice currently. Finally, the finding in this study, and in others, that non-reassuring fetal status is one of the main indications for a primary CS in obese nulliparous suggests a need for better tools to monitor fetal status in laboring obese women. Since "non-reassuring fetal status" by CTG is poorly predictive of fetal asphyxia, future research on methods and technologies to help distinguish fetuses in trouble from those who can be allowed continued labor may help reduce unplanned CS rates in those women.

CONCLUSION

Our study shows that high maternal BMI per se does not appear to be an independent risk factor for unplanned CS in healthy nulliparous women presenting at term with a singleton pregnancy in spontaneous labor.

LIST OF JOURNAL ABBREVIATIONS

Am J Obstet Gynecol	American Journal of Obstetrics and Gynecology
Am J Epidemiol	American Journal of Epidemiology
Am J Perinatol	American Journal of Perinatology
Aust N Z J Obstet Gynaecol	Australian and New Zealand Journal of Obstetrics and Gynaecology
BJOG Int J Obstet Gynaecol	BJOG: An International Journal of Obstetrics and Gynaecology
Cochrane Database Syst Rev	Cochrane Database of Systematic Reviews
Curr Opin Endocrinol Diabetes Res	Current Opinion in Endocrinology, Diabetes, and Obesity
Eur J Obstet Gynecol Reprod Biol	European Journal of Obstetrics & Gynecology and Reproductive Biology
Gynecol Obstet Invest	Gynecologic and Obstetric Investigation
J Obstet Gynecol Neonatal Nurs	Journal of Obstetric, Gynecologic, and Neonatal Nursing
Matern Child Health J	Maternal and Child Health Journal
Med J Aust	Medical Journal of Australia
Minerva Pediatr	Minerva Pediatrica
Obes Rev	Obesity Reviews
Obstet Gynecol	Obstetrics and Gynecology
Reprod Sci	Reproductive Sciences
Rev Port Pneumol	Revista Portuguesa de Pneumologia

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