TITLE PAGE
“Weight Gain during Pregnancy and Risks of Caesarean Section”

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ABSTRACT

AIMS
To ascertain the association between weight gain during pregnancy and the risk for caesarean delivery.

METHODS
Retrospective cohort study was conducted. The samples were women carrying singleton pregnancy who delivered a live-born infant at Khon Kaen Hospital between June and September 2010. Women who had multiple pregnancies, previous history of caesarean section, congenital fetal anomaly and intrauterine fetal dead were excluded.

RESULTS
The principle outcome occurred in 1,039 patients. We found that mothers with weight gain during pregnancy excess the Institute of Medicine (IOM) recommendation had significantly higher rate of caesarean section than women gained weight within the IOM recommendation (relative risk (RR), 1.26; 95% confident interval (CI), 1.07 to 1.48) and when we examined their relationship adjusted by maternal age and body mass index (BMI). We found that the risk of caesarean delivery was slightly significantly increased in the overweight mothers, age 20-35, (RR, 1.99; 95% CI, 1.11 to 3.58).

CONCLUSION
Excessive weight gain during pregnancy had an effect on caesarean section rate, but it was not the only predictor of caesarean section. Maternal age and BMI were also the important confounders in this relationship. Excess weight gain during pregnancy alone was weakly associated with higher rate of caesarean delivery.

MAIN TEXT

The global rate of caesarian section has been steadily rising, especially in high income countries.[1] The US Center for Disease Control's National Center for Health Statistics revealed that our of more than 4 millions babies born in 2007 in the US, 31.8% were delivered via cesarean section.[2] The caesarian section incurs high cost and morbidity in health care system in most countries, and can lead to unpredictable complications e.g., post operative adhesion, intestinal obstruction and intraoperative hemorrhage.[3-5] Although the complications are found occasionally, it is suggested that the caesarian section should not be operated in non-medically necessary cases due to its risks and cost.[6]

It has been long known that caesarian section is indicated in women with cephalopelvic disproportion, previous classical caesarean section, fetal distress, eclampsia, unsuccessful trial of forceps or vacuum, placenta previa totalis, some types of abnormal presentation, fetal macrosomia active genital herpes and multiple pregnancy.[7-10]

In the recent systematic review and previous studies, maternal body mass index (BMI) and the weight gain during pregnancy was found to be predictor for higher risk of caesarian section in both elective and emergency conditions, especially in obese and overweight women. However, their findings were inconsistent and relied on only fair to moderate strength of evidences from solely European countries and North America Continent.[11-14] Also there is no other strong evidences support their association.[14] Thus, in this study, we aimed to examine the association between gestational weight gain and cesarean delivery rate in the subgroup of Asian population according to the fact that with the same BMI the Asians give higher percentage of fat than that of the Europeans which leads to higher risk of many disease e.g., hypertension and diabetes. Hence lower cut-off point of BMI in Asian population should be applied. [15]

METHODS

Study Design

This is a retrospective cohort study determining the relationship between weight gain during pregnancy and the rate of caesarean delivery rate

Participants and study site

This study was conducted in Department of Obstetrics and Gynecology, Khon Kaen Hospital. Participants were women carrying singleton pregnancies who delivered a live-born infant between June and September 2010. All pregnant women who had history of previous caesarian section, elective cases that were willing to have caesarian deliveries without medical indications and dead fetus in utero were excluded. The sample size calculation was based on the assumption that the overall caesarean section rate would be at least 20% difference between the group with normal weight gain during pregnancy and those with weight gain excess the IOM recommendation. From the preliminary analysis of the collected sample, the rate of cesarean delivery was about 65% in those with weight gain excess the IOM recommendation while only 22% in those with normal weight gain. Thus, with 80% of power and 5% alpha error, the required sample would be at least 15 in both groups. However, the included more than one thousand pregnant women for the best approximate of the results.

Data collection

Variables regarding the mothers including age, parity, gestational age estimated either by ultrasonographic method or last menstrual period (LMP), height, pregravid and predelivery weight, smoking habit and alcohol consumption, as well as variables regarding the infants including sex, birth weight and APGAR score at 10 minutes after birth were collected from medical records. All data were double entried into the excel spreadsheet, cleaned and verified before the analysis.

Statistical analysis

All numeric data were test for their distribution using Kolmogorov-Smirnov test. For non-normal distributed data, they were expressed as median and the interquartile range (IR). Comparisons the baseline characteristics of the mothers in four groups regarding their BMI were performed using Kruskal-Wallis test. We used either Chi-square test or Fisher's exact test to compare the two groups with respect to the primary outcome-the proportion of women who had caesarean delivery. The relative risk of caesarean delivery

and 95% confidence intervals (CIs) were calculated for the weight gain within the IOM recommendation group compared with the weight gain excess the IOM recommendation group. To answer questions regarding proper gestational weight gain in Thai women, we used Receiver Operating Characteristic curve.

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Figure 1 here

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RESULTS

There were 1,430 women included in the study, 203 were excluded as the mother had history of previous caesarean section, had multiple pregnancy, death fetus in utero (DFIU) or fetal anencephaly. Finally, there were 1,227 left for the analysis (Figure 1). Their baseline characteristics are shown in Table 1. They had a median age of 25 years old (IR, 20.0 – 29.0). Most of them were nulliparous (61.1%). Their median gestation ages and BMI were about 39 weeks (IR, 37.8 to 40.0) and 20.5 (IR, 18.7 to 23.1) respectively. Almost all of them were non- smoker and did not drink alcohol. The infant sex tended to be male (51.4%). The median of infant birth weight was 3,030 grams (IR, 2,730 to 3,330). Furthermore, nearly all of the APGAR score of the infants at 10 minutes after birth were 10 (98.1%).

We categorized the mothers by their BMI into four groups. The mothers with high BMI tended to gain weight excess the IOM recommendation and likely to be older. The mothers with low BMI tended to have greater chance of preterm labor. Maternal height and the infant's APGAR score were the only two variables that were not statistically different across the four groups.

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Table 1 here

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The optimal cut-off value for the weight gain during pregnancy in predicting delivery route was estimated using ROC curve, illustrated in Figure 2. However, at any cut off point value, there seems to be no large difference between true positive (sensitivity) and false positive (1-specificity). Moreover, the overall areas under the Receiver operating characteristic (ROC) curve are approximately 0.6. Thus, using the weight gain during pregnancy alone is not likely to be able to predict the rout of delivery.

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Figure 2 here

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Neonatal and delivery outcomes are shown in Table 2. Most of the newborn were normal weight and had APGAR score of ten in both groups. The infants of mother who had weight gain within IOM recommendation tended to have normal birth weight more than those of mothers with weight gain excess than IOM recommendation. Moreover, there were no differences between those with weight gain within and excess the IOM recommendation in relation to preterm and postterm of deliveries.

Regarding the primary outcomes of the present study, the mother with weight gain during pregnancy excess the IOM recommendation had significantly higher rate of caesarean section compared with whose weight gained within IOM recommendation (RR, 1.26; 95% CI, 1.07 to 1.48) (Table 2). However, when we examined the relationship between weight gain and rate of caesarean delivery regarding BMI and maternal age, we found that only the over weight mothers age 20-35, the risk of caesarean delivery was significantly increased (RR, 1.99; 95% CI, 1.11 to 3.58)(table 3).

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Table 2 here

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DISCUSSION

The rate of caesarean delivery was significantly associated with varies of maternal conditions including weight gain during pregnancy.[1,7-15] According to many researches, despite they provided the association between maternal weight gain during pregnancy and caesarean section rate, there was no studies that are likely to be able to generalize to Thai population. Even more there is no standard guideline for Asian population. The IOM recommendation cannot be applied to use with the Asians due to differences of BMI.[15] In this study we focused on maternal weight gain excess or within the IOM recommendation and used of Asian's BMI instead of the World Health Organization (WHO) BMI. We found that the maternal weight gain had influence on caesarean section rate, but when we adjusted all the confounders (BMI and maternal age), surprisingly the outcomes suggested that there was weakly statistically significant in differences between the mother who had weight gain excess the IOM recommendation and those who gained within the recommendation.

The results of this study suggested that pregnant women those who had weight gain during pregnancy excess the IOM recommendation were likely to have more risk of caesarean section, especially in overweight women. As in many studies, there were varies of factors that had influence on caesarean section rate.[1,7-14]but there was no study focused exclusively on weight gain during pregnancy. In our analyses, we selected a group of women with singleton pregnancies who delivered a live-born infant and categorized them into four groups of BMI and three groups of maternal age in order to focus on the effect of maternal weight gain on caesarean section rate without confounding by maternal age and BMI. However, our study is a retrospective cohort study, missing data cannot be recollected in some cases, consequently cannot be analyzed may lead to biased study results. Nonetheless, the attempts to verify and complete all missing data were made. Still, approximately 14% of the primary outcome (weight gain during pregnancy) was missing.

From our study, the important problem is many missing data could not be recorded due to retrospective cohort study design. Subjective recorded data such as smoking habit and alcohol consumption might not be exactly accurate. For the confirmation of the relationship between weight gain and caesarean delivery as well as

other maternal and neonatal outcomes, the prospectively cohort study with larger samples should be conducted. We thought that cross sectional study is a better option but it may take a long time. Although our study shows only weak relationship between weight gain during pregnancy and risk of caesarean section, it is undeniable that weight control still be important, especially in overweight woman with age from 20 to 35.

In summary, excessive weight gain during pregnancy had influences on caesarean section rate, but it was not the only predictor of caesarean section. Maternal age and BMI were also the important confounders in this relationship. Excess weight gain during pregnancy alone was weakly associated with higher rate of caesarean delivery.

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COMPETING INTERESTS

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TABLES

Table1. Baseline Characteristics of the Patients.					
Variable	BMI				P value
	Underweight (BMI < 18.5) (N=237)	Normal (BMI = 18.5-23.0) (N=532)	Overweight (BMI 23-27) (N=186)	Obese (BMI ≥ 27) (N=85)	
Age-Year					0.000
Median	23.0	25.0	27.0	27.0	
Interquartile range	19.0 - 26.0	20.0 - 29.0	23.0 - 31.0	22.0 - 30.5	
Parity-no. (%)					0.000
Nulliparous	169 (71.3)	335 (63.0)	85 (45.7)	46 (54.1)	
Multiparus	68 (28.7)	197 (37.0)	101 (54.3)	39 (45.9)	
Gestational age-no. (%)					0.019
Less than 37 weeks.	48 (20.3)	87 (16.4)	27 (14.5)	5 (5.9)	
37 to 42weeks.	184 (77.6)	441 (82.9)	155 (83.3)	80 (94.1)	
More than 42 weeks.	5 (2.1)	4 (2.2)	4 (2.2)	0	
Median	38.8	39.0	39.0	39.1	
Interquartile range	37.3 - 40.0	38.0 - 39.8	37.9 - 40.0	38.1 - 40.1	
Height-centimeter					0.060
Median	158	156.5	157.0	158.0	
Interquartile range	155.0 - 163.0	153.0 - 161.0	153.0 - 161.0	153.0 - 163.0	
Gestational weight gain regarding to IOM* recommendation-no. (%)					0.000
Normal weight gain	192 (81.0)	378 (71.2)	69 (37.3)	25 (29.4)	
Excess Weight gain	45 (19.0)	153 (28.8)	116 (62.7)	60 (70.6)	
Smoking habit-no. (%)					0.418
Never	207 (100.0)	524 (98.5)	185 (99.5)	83 (97.6)	
Stopped before pregnancy	0	3 (0.6)	0	1 (1.2)	
Still Smoking	0	5 (0.9)	1 (0.5)	1 (1.2)	
Alcohol drinking-no. (%)					0.739
Never	233 (98.3)	522 (98.1)	185 (99.5)	85 (100.0)	
Stopped before pregnancy	2 (0.8)	5 (0.9)	0	0	
Still drinking	2 (0.8)	5 (0.9)	1 (0.5)	0	
Infant sex-no. (%)					0.144
Male	126 (53.2)	261 (49.1)	108 (58.1)	40 (47.1)	
Female	111 (46.8)	271 (50.9)	78 (41.9)	45 (52.9)	
Infant birth weight					0.027
Very low birth weight (< 1,500 g)	3 (1.3)	7 (1.3)	2 (1.1)	0	
Low birth weight (1,500 - 2,500 g)	23 (9.7)	63 (11.8)	17 (9.1)	4 (4.7)	
Normal birth weight (2,500 - 4,000 g)	209 (88.2)	455 (85.5)	159 (85.5)	76 (89.4)	
High birth weight (> 4,000 g)	2 (0.8)	7 (1.3)	8 (4.3)	5 (5.9)	
Median	2,950	3,030	3,190	3,260	

Interquartile range	2,730.0 -3,205.0	2,730.0 -3,310.0	2,795.0 -3,430.0	2,915.0 -3,945.0	
APGAR score					0.638
0	1 (0.4)	0	1 (0.5)	0	
1 - 5	0	3 (0.6)	0	1 (1.2)	
6 - 9	5 (21)	7 (1.3)	1 (0.5)	1 (1.2)	
10	231 (97.5)	532 (98.1)	184 (98.9)	83 (97.6)	
* institute of medicine[14]					

Table.2 Secondary Outcomes.			
outcome	gestational weight gain		Relative risk (95% CI)
	Weight gain excess than IOM recommendation (N=374)	Weight gain within IOM recommendation (N=664)	
Caesarean section-no. (%)	132 (35.3)	182 (24.4)	1.26 (1.07-1.48)
Infant birth weight			
Very low birth weight (<1,500 g)	3 (0.8)	9 (1.4)	0.69 (0.26-1.85)
Low birth weight (1,500-2,500 g)	28 (7.5)	79 (11.9)	0.70 (0.51-0.98)
Normal birth weight (2,500-4,000 g)	332 (88.8)	565 (85.1)	1.04 (0.99-1.09)
High birth weight (> 4,000 g)	11 (2.9)	11 (1.7)	1.40 (0.91-2.14)
APGAR score			
0	1 (0.3)	1 (0.2)	1.39 (0.35-5.57)
1 - 5	1 (0.3)	3 (0.5)	0.69 (0.13-3.79)
6 - 9	3 (0.8)	11 (1.7)	0.59 (0.22-1.62)
10	369 (98.7)	649 (97.7)	1.45 (0.68-3.11)
Preterm labor	50 (13.4)	117 (17.6)	0.80 (0.63-1.03)
Post term	5 (1.3)	8 (1.2)	1.07 (0.53-2.14)

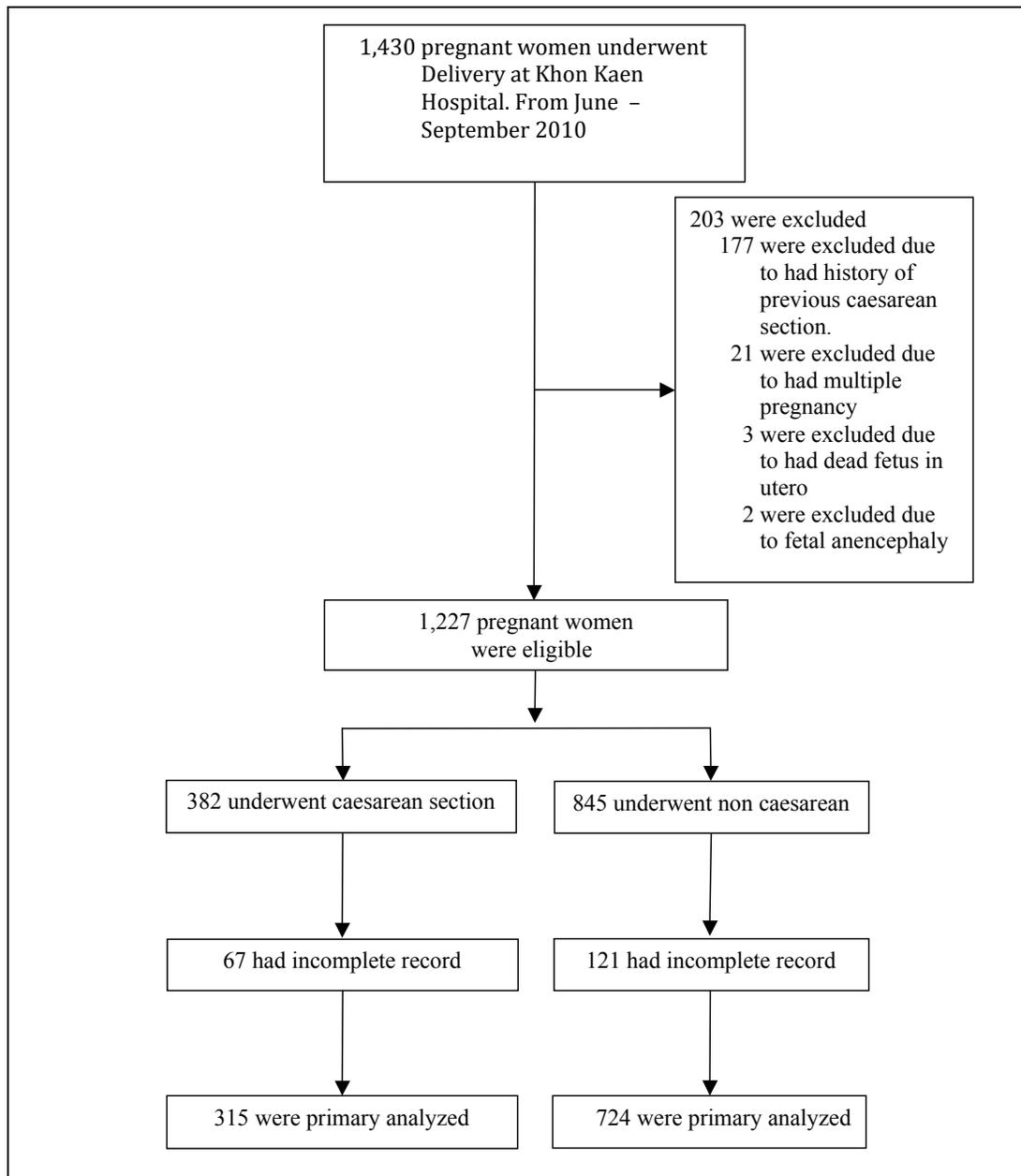| Table.3 Primary Outcomes.			
outcome	Mode of delivery		Relative risk (95% CI)
	Caesarean delivery	Vaginal delivery	
Weight gain excess than IOM recommendation-no%			
Teenage (<20)			
Underweight (BMI < 18.5)	3 (37.5)	14 (18.9)	2.29 (0.61 - 8.66)
Normal (BMI = 18.5- 23.0)	5 (20.8)	36 (31.1)	0.64 (0.25 - 1.59)
Overweight (BMI 23-27)	9 (81.8)	17 (81.0)	1.04 (0.30 - 3.62)
Obese (BMI ≥ 27)	6 (85.7)	5 (71.4)	1.64 (0.30 - 8.86)
Normal (20-<35)			
Underweight (BMI < 18.5)	11 (23.9)	17 (15.9)	1.40 (0.82 - 2.41)
Normal (BMI = 18.5- 23.0)	28 (24.8)	70 (28.9)	0.86 (0.60 - 1.24)
Overweight (BMI 23-27)	33 (75.0)	47 (52.8)	1.99 (1.11 - 3.58)
Obese (BMI ≥ 27)	25 (86.2)	21 (63.6)	2.17 (0.90 - 5.29)
Elderly (>35)			
Normal (BMI = 18.5- 23.0)	6 (40.0)	8 (38.1)	1.05 (0.48 - 2.30)
Overweight (BMI 23-27)	5 (45.5)	5 (55.6)	0.83 (0.38 - 1.86)
Obese (BMI ≥ 27)	1 (20.0)	2 (50.0)	0.50 (0.09 - 2.73)

FIGURES AND IMAGES

Figure1. Enrollment of patient and assessment of primary outcome.
The relationship between weight gain during pregnancy and risk of caesarean delivery was assessed. The study was analyzed in women carrying singleton pregnancy who underwent delivery at Khon Kaen Hospital. These excluded the women who had dead fetus in utero, a history of previous caesarean section, severe congenital fetal anomaly and incomplete data of pregravid weight.

Figure2. Receiver operating characteristic (ROC) curves for maternal weight gain during pregnancy in relation to caesarean delivery rate.
Underweight (BMI < 18.5) (Panel A). Normal weight (BMI 18.5- 23.0) (Panel B). Overweight (BMI 23-27) (Panel C). Obese (BMI ≥ 27) (Panel D).