Outcomes of Gestational Weight Gain Outside the Institute of Medicine Guidelines

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Objective: *To compare pregnancy outcomes between women who gave birth at Lerdsin Hospital having gestational weight gain (GWG) within and above or below Institute of Medicine (IOM) guidelines.*

Material and Method: *All medical records of women who gave birth at Lerdsin Hospital between October 1, 2010 and September 30, 2013 were reviewed. Three thousands six hundred eighty three women who met inclusion criteria were divided into four categories according to pre-pregnancy body mass index (BMI) as underweight, normal weight, overweight and obese. Women in each categories were compared for outcomes (neonatal birth weight, cesarean birth, pregnancy induced hypertension (PIH), gestational diabetes (GDM), preterm birth, low birth weight (LBW), macrosomia, small for gestational age (SGA) and large for gestational age (LGA)), using logistic regression to calculate odds ratios (ORs) and 95% confidence intervals (CIs).*

Results: *Of 3,683 pregnant women, 34.9% had weight gain within, 36.5% above, and 28.7% below IOM guidelines. Women with higher gestational weight gain in all BMI categories had an increased risk of cesarean birth (except in obese group), macrosomia, LGA and a decreased risk for preterm birth, LBW (except for overweight group) and SGA. Women with lower gestational weight gain had an increased risk for preterm birth, LBW, SGA and a decreased risk for cesarean birth. Neonates delivered from women whose gestational weight gains were above IOM guidelines were also heavier than those from neonates whose maternal weight gains during pregnancy were within IOM guidelines.*

Conclusion: *The IOM guidelines are useful for monitoring gestational weight gain and if it were within guidelines, women could have decreased risk for several adverse outcomes such as cesarean birth, macrosomia, LGA, preterm birth, LBW and SGA.*

Keywords: *Institute of Medicine (IOM), Pre-pregnancy BMI, Gestational weight gain (GWG), Cesarean birth, Preterm birth, Low birth weight (LBW)*

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In 2009, IOM[1] revised the guidelines for weight gain during pregnancy previously issued in 1990 and formulated a range of GWG for 4 categories of pre-pregnancy body mass index (BMI) as underweight women (BMI <18.5 kg/m^2) whose GWG should be 12.5-18 Kg, normal weight women (BMI 18.5-24.9 kg/m^2) whose GWG should be 11.5-16 Kg, overweight women (BMI 25-29.9 kg/m^2) whose GWG should be 7-11.5 Kg. and obese women (BMI >30 kg/m^2) whose GWG should be 5-9 Kg. The IOM suggested that women whose GWG are outside the recommended ranges may experience various adverse maternal and neonatal outcomes such as pregnancy induced hypertension (PIH), gestational diabetes mellitus (GDM), preterm birth, low birth weight (LBW), small for gestational age (SGA), macrosomia, large for gestational age (LGA) as well as other long term consequences such as post-partum weight retention and obesity later in life of the newborn.

In Thailand, it is questionable whether the above recommendations are suitable for pregnant Thai women. The purpose of the present study is to compare pregnancy outcomes between women who gave birth at Lerdsin Hospital having GWG within IOM guidelines with those whose GWG were above or below IOM guidelines in terms of neonatal birth weight, cesarean birth, PIH, GDM, preterm birth, LBW, macrosomia, SGA, and LGA.

Material and Method

This is a retrospective study from the medical records of women who gave birth at Lerdsin Hospital between October 1, 2010 and September 30, 2013, after receiving approval from the Lerdsin Hospital Ethical Committee. Inclusion criteria were singleton pregnant women who had complete records of pre-pregnancy weight, height, body weight at the day of

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delivery and gestational age. Gestational age was calculated from LMP or records of early ultrasound examination before 20 weeks of gestation. Pre-pregnancy weight was obtained by self-reported at the day of delivery or from ante-natal care records. Maternal body weight was measured at labor ward on the day of delivery. Exclusion criteria were women who delivered before 24 weeks of gestation, women with fetal death in utero before delivered and women whose neonates were found to have any major congenital malformations.

Data of maternal age, race, parity, education background, gestational age, pre-pregnancy weight, maternal height, BMI, body weight at the day of delivery, gestational weight gain, mode of delivery, and the outcomes for the present study (e.g. neonatal birth weight, cesarean birth, PIH, GDM, preterm birth, LBW, macrosomia, SGA, and LGA) were collected and recorded in the case report forms (CRF) for analysis. Preterm birth was defined as delivery before 37 weeks of gestation. Low birth weight (LBW) was birth weight below 2,500 grams. Macrosomia was birth weight at or above 4,000 grams. LGA and SGA were birth weight above and below 90th and 10th centile respectively calculated from girls and boys research data for Fenton 2013 weight calculator[2]. PIH included women with gestational hypertension, preeclampsia, and eclampsia. GDM included GDM class A1 and A2 according to White classification[3].

Statistical analysis

All subjects were divided into four categories of pre-pregnancy BMI as suggested by IOM. SPSS13 (SPSS Inc., version 13.0, Chicago IL, USA) was used for statistical analysis. Mean, standard deviation, frequency, and percentage were used to analyze baseline data such as age gestational age, race, education level, neonatal weight. One-way analysis of variance (ANOVA) was used to compare continuous data and Chi-square test was used to compare discrete data among groups. The *p*-value of less than 0.05 was considered to be statistically significant difference. Women in each pre-pregnancy BMI categories were further divided into those who gained weight within, above, and below IOM guidelines. Logistic regression was used to calculate odds ratios (ORs) and 95% confidence intervals (CIs) for outcomes (except neonatal birth weight) based on total GWG above and below IOM guidelines. The reference group in each pre-pregnancy BMI category was women whose weight gains were within IOM guidelines. Adjustments were made for maternal age, race, parity, and pre-pregnancy BMI, which were determined as potential confounders. Differences in mean neonatal birth weight between neonates born from mothers whose gestational weight gain were above, below and within IOM guidelines were compared using Student's t-test.

Results

Of the 6,722 women who were delivered at Lerdsin Hospital between October 1, 2010 and September 30, 2013, 3,683 women fit our inclusion criteria. The baseline characteristics of the study population were shown in Table 1.

Differences in mean birth weight between neonates born from women whose GWG were above, below and within IOM guidelines were compared and shown in Table 2, using Student's t-test for statistical analysis. Neonates born from mothers whose GWG were above IOM guidelines were significantly heavier than those whose mothers gained within guidelines in all BMI groups. Neonates born from women whose GWG were below IOM guidelines were significantly lighter than those from women whose gestational weight gain were within IOM guidelines only in underweight and normal weight BMI groups.

Binary logistic regression was used to compare outcomes from women who gained weight above and below IOM guidelines with women who gained within the guidelines. After adjusting for maternal age, race, parity and pre-pregnancy BMI, women who gained weight above IOM guidelines were at increasing risk of developing PIH, giving birth to macrosomia neonates, LGA neonates and delivering by cesarean section (except in obese group) as shown in Table 3. They were also less likely to deliver preterm, LBW (except in overweight group) and SGA neonates (except in obese group).

Women who gained weight less than IOM recommendation (Table 4) had reduced risk for cesarean delivery and LGA neonates, but increased risk for LBW and SGA neonates than those who gained weight as IOM recommended. These women were also at increased risk for developing GDM and preterm birth, although it was not seen in overweight group. PIH were not found in any obese women who gained less weight than IOM recommendation in the present study. The author could not find any macrosomia neonates from women who gained less than IOM recommendation too.

Table 1. Baseline data by pre-pregnancy BMI (n = 3,683)

	Underweight (n = 625)	Normal weight (n = 2306)	Overweight (n = 575)	Obese (n = 177)	*p*-value
Age(years)	25.6±5.4	28.0±5.8	30.2±5.7	29.6±6.0	<0.01
Gestational age at delivery (weeks)	38.2±1.9	38.4±1.7	38.4±1.6	38.3±1.8	0.08
Race					<0.01
Thai	508 (81.3)	1,635 (70.9)	425 (73.9)	145 (81.9)	
Foreign	117 (18.7)	671 (29.1)	150 (26.1)	32 (18.1)	
Education					<0.01
Primary school or lower	159 (25.4)	920 (39.9)	266 (46.3)	68 (38.4)	
Secondary school	371 (59.4)	1,041 (45.1)	227 (39.5)	82 (46.3)	
Diploma degree or higher	95 (15.2)	345 (15.0)	82 (14.3)	27 (15.3)	
Number of women who gained weight					<0.01
Above IOM (n = 1,341)	139 (22.2)	784 (34.0)	314 (54.6)	104 (58.8)	
Within IOM (n = 1,285)	255 (40.8)	791 (34.3)	181 (31.5)	58 (32.8)	
Below IOM (n = 1,057)	231 (37.0)	731 (31.7)	80 (13.9)	15 (8.5)	
Parity					<0.01
1	402 (64.3)	1,210 (52.4)	196 (34.1)	60 (33.9)	
2	165 (26.4)	840 (36.4)	265 (45.9)	75 (42.4)	
≥3	58 (9.3)	256 (11.1)	114 (19.8)	42 (23.7)	
Mode of Delivery					<0.01
Normal labor	424 (67.8)	1,338 (58.0)	271 (47.1)	72 (40.7)	
Cesarean section	170 (27.2)	883 (38.3)	288 (50.1)	103 (58.2)	
Other (F/E,V/E, breech assisting)	31 (5.0)	85 (3.7)	16 (2.8)	2 (1.1)	
Mean neonatal weight (grams)	2,955.5±435.3	3,080.2±451.0	3,245.2±476.9	3,240.4±486.8	<0.01

BMI = body mass index; IOM = Institute of Medicine; F/E = forceps extraction; V/E = vacuum extraction
Continuous data shown as mean ± SD, discrete data shown as n (%)

Table 2. Comparisons of differences in mean birth weight (grams) between neonates born from women whose gestational weight gains were above, below and within IOM guidelines classified according to pre-pregnancy BMI (n = 3,683)

Compared groups	Differences in mean birth weight (grams)			
	Underweight (n = 625)	Normal weight (n = 2306)	Overweight (n = 575)	Obese (n = 177)
Below IOM vs. within IOM	-202.9±38.5 (p<0.01)	-129.5±22.3 (p<0.01)	13.4±61.3 (p = 0.83)	-11.9±150.5 (p = 0.94)
Above IOM vs. within IOM	127.8±41.9 (p<0.01)	153.5±22.1 (p<0.01)	111.6±43.9 (p<0.01)	167.0±83.1 (p = 0.04)

Differences between 2 groups were derived by subtracting mean birth weight of those within IOM group from mean birth weight of those below IOM and above IOM group respectively. Statistical values derived from using Student's t-test
Data shown as differences of mean ± SE

Discussion

In the present cohort of 3,683 pregnant women, 1,285 (34.9%) women gained weight within IOM guidelines, while 2,398 (65.2%) women gained weight outside the IOM guidelines, in which 1,341 (36.5%) and 1,057 (28.7%) had GWG above and below the IOM guidelines, respectively. When comparing between women who gained weight within and outside the IOM guidelines, the author found three important trends in this cohort of women. First, there were higher risk for cesarean delivery in women who gained weight above IOM guidelines (except in obese group), and lower risk in those who gained weight below IOM guidelines compare to women who gained weight within IOM guidelines. Second, those who gained weight below IOM guidelines tended to had higher risk for preterm birth, LBW, and SGA neonates than those who gained within IOM guidelines, while

Table 3. Outcomes among women gaining weight above IOM guideline[a] (n = 3,683)

Outcomes	Underweight OR (95% CI) (n = 625)	Normal weight OR (95% CI) (n = 2,306)	Overweight OR (95% CI) (n = 575)	Obese OR (95% CI) (n = 177)
Cesarean delivery[b]	1.16 (0.69-1.94)	1.30 (1.03-1.65)	1.64 (1.05-2.58)	0.85 (0.37-1.97)
Pregnancy induced hypertension (PIH)	4.74 (0.90-24.82)	1.52 (0.87-2.66)	1.41 (0.61-3.28)	1.61 (0.53-4.88)
Gestational diabetes	1.05 (0.09-11.95)	0.72 (0.33-1.56)	0.85 (0.35-2.07)	1.22 (0.40-3.73)
Preterm birth	0.81 (0.40-1.61)	0.52 (0.35-0.77)	0.77 (0.37-1.58)	0.56 (0.17-1.86)
Low birth weight	0.40 (0.15-1.09)	0.41 (0.26-0.66)	1.18 (0.49-2.84)	0.45 (0.11-1.76)
Macrosomia	4.90 (0.49-49.36)	3.31 (1.75-6.28)	1.99 (0.87-4.58)	4.46 (0.50-39.42)
Small for gestational age[c]	0.72 (0.40-1.30)	0.78 (0.58-1.05)	0.84 (0.39-1.79)	1.68 (0.42-6.67)
Large for gestational age[d]	1.52 (0.40-5.80)	2.28 (1.31-3.97)	1.09 (0.52-2.29)	1.99 (0.59-6.72)

OR = odds ratio; CI = confidence interval

[a] Adjusted for maternal age, race, parity and pre-pregnancy BMI. Reference group is women gaining weight within the IOM guideline

[b] Cesarean delivery were adjusted by excluding cases with previous cesarean section

[c] Small for gestational age defined as birth weight below the 10th percentile

[d] Large for gestational age defined as birth weight above the 90th percentile

Table 4. Outcomes among women gaining weight below IOM guideline[a]

Outcomes	Underweight OR (95% CI) (n = 625)	Normal weight OR (95% CI) (n = 2,306)	Overweight OR (95% CI) (n = 575)	Obese OR (95% CI) (n = 177)
Cesarean delivery[b]	0.55 (0.34-0.91)	0.80 (0.62-1.03)	0.92 (0.47-1.78)	0.53 (0.12-2.33)
Pregnancy induced hypertension (PIH)	1.13 (0.16-8.20)	0.64 (0.32-1.27)	1.41 (0.23-8.52)	NA
Gestational diabetes	1.87 (0.30-11.67)	1.84 (0.98-3.43)	2.21 (0.82-6.01)	2.35 (0.46-11.90)
Preterm birth	1.74 (1.03-2.94)	1.54 (1.11-2.15)	0.94 (0.34-2.57)	2.12 (0.45-10.00)
Low birth weight	3.23 (1.86-5.63)	1.71 (1.21-2.43)	1.10 (0.32-3.79)	1.63 (0.28-9.66)
Macrosomia	NA	0.32 (0.11-0.90)	1.08 (0.31-3.71)	4.01 (0.23-70.79)
Small for gestational age[c]	2.16 (1.39-3.33)	1.76 (1.35-2.30)	1.16 (0.41-3.26)	9.38 (1.79-48.96)
Large for gestational age[d]	0.44 (0.08-2.31)	0.45 (0.21-0.98)	0.35 (0.07-1.59)	0.93 (0.09-9.26)

OR = odds ratio; CI = confidence interval

[a] Adjusted for maternal age, race, parity and pre-pregnancy BMI. Reference group is women gaining weight within the IOM guideline

[b] Cesarean delivery were adjusted by excluding cases who were diagnosed with previous cesarean section

[c] Small for gestational age defined as birth weight below the 10th percentile

[d] Large for gestational age defined as birth weight above the 90th percentile

NA were due to low incidence

those who gained weight above IOM guidelines tended to be less risk for these factors (except for LBW in overweight group). Third, women whose GWG were above IOM guidelines had more risk for delivering macrosomia, LGA neonates, and heavier neonates than women whose GWG were within IOM guidelines, while women whose GWG were below IOM guidelines had less risk for LGA neonates than women who gained weight within IOM guidelines.

These outcomes are in line with report from IOM and several studies[1,4-6]. Some studies in Thai women[7,8] also found the same associations as in the present study in terms of lower gestational weight gain and preterm birth, SGA, and LBW. They also found that high gestational weight gain is associated with higher neonatal birth weight although using different criteria for gestational weight gain.

Viswanantha[5] concluded from 21 studies that there was moderate evidence to show that higher GWG

had some degree of association with cesarean delivery and the association appeared to be stronger among overweight and obese women. Although the present study was in line with these results, the author did not see this in obese women. The present study excluded cases with previous cesarean delivery, which would result in cesarean delivery for all subsequent pregnancies in Lerdsin Hospital, while several studies from the review did not take into account prior route of delivery. The definitions of gestational weight gain and adjusted factors for confounders varied greatly from the present study, which might be the cause of difference.

Evidence for an association between low GWG and low birth weight was observed in the present study, and it appeared to be stronger among women of underweight and normal weight women than among overweight and obese women. This is in line with the report from IOM and several studies[9,10]. Although the IOM concluded that in general as gestational weight gain increased, LBW decreased. The author could not see such effect in the overweight women in the present study. One study in Thailand[7] suggested using weight gain per week (≥0.27 Kg) in normal weight BMI Thai women as a guideline to reduce LBW. One study in New York City reported a protective effect for LBW in women who gained more than 41 pounds (18.6 Kg) compared with women who gained less than 41 pounds[11]. A study in Denmark found that the risk of LBW was significantly reduced only for underweight women gaining at least 12 kg when compared to underweight women gaining less than 11 kg[12].

In the present study, women who gain weight above IOM guidelines in all BMI categories tended to have higher risk for PIH than women who gain weight within IOM guidelines, while there were inconsistent associations in women who gain weight less than IOM guidelines. The relationship between increase gestational weight gain and PIH remains inconclusive. Several studies[9,13-15] found that increasing weight gain was associated with increasing likelihood of a pregnancy-induced hypertensive disorder as in our study. Two studies[10,16] did not support this association. PIH is multiple factors in origin, resulting in increase vascular permeability and decrease intra-vascular volume, which can lead to increased edema and excessive weight gain so that PIH could be the cause rather than effect of high gestational weight gain.

Women from all four BMI categories in the present study who gained weight below IOM guidelines, tended to have higher risk for GDM than women who gain weight within IOM guidelines. This was in line with some studies[7,15,17] but in contrast to other studies[18,19] that reported that gestational weight gain above the recommended range by IOM was positively associated with abnormal glucose tolerance. Management of women with GDM includes dietary counseling so that their diet would be modified in such a way that limits their weight gain. The evidence so far from IOM concluded that the association between gestational weight gain and abnormal glucose tolerance is weak.

The limitations of the present study included pre-pregnancy weight records that were self-reported and might not be accurate, and lead to overestimation or underestimation of gestational weight gain. Some of the subgroups were also relatively small. Therefore, some of the differences may not be detected or lack of power in these subgroups, we believed if larger or calculated sample size in all pre-pregnancy BMI categories were used, we could draw a stronger correlation.

Pre-pregnancy BMI and GWG are two important factors associate with maternal and neonatal outcomes in pregnancy that are still neglected by health personnel performing antenatal care. All women should be encouraged to control their body weight to achieve normal BMI before pregnancy especially obese women as they possess increasing maternal and neonatal risks[20,21]. There is a trend toward obesity in pregnancy all over the world including Thailand[22] and these women should be encouraged to limit weight or even lose weight[9,23] to achieve better maternal and neonatal outcomes. Although the IOM guidelines are useful tool for overseeing women during pregnancy, appropriate gestational weight gain for each BMI categories should be sought out in Thai women. Titapant V, Lertbunnaphong T and Pimsen S[24] reported that for Thai women with normal pregnancy outcomes, less than half of them gained the appropriate weight based on IOM recommendation. Sunsaneevithayakul et al[25] suggested GWG different from IOM with better adherence in Thai women and significantly decreased adverse pregnancy outcomes. This should prompt more studies for appropriate gestational weight gain in Thai women. More efforts should be put on to encourage healthy lifestyles using GWG as one of the indicators of wellbeing. Data on GWG should be collected and evaluated as a new comprehensive metric of progress in ante-natal care. This is because it is easy to do and it tells us whether women are still okay or not. Dietary counseling and programed physical activities during

pregnancy[26] should be given to all women visiting ante-natal care clinics especially in obese women to achieve appropriate gestational weight.

In conclusion, using gestational weight gain for different pre-pregnancy BMI groups as recommended by IOM, and encourage women to achieve these goals can reduce incidences of cesarean birth, pre-term birth, LBW, SGA neonates, macrosomia, and LGA neonates, which are both short-term and long-term important risks and burdens posed on Thai women and children. We should also have more studies to find the appropriate gestational weight gain for each pre-pregnancy BMI category in Thai women.

What is already known on this topic?

Previous study from the Institute of Medicine (IOM) has shown that pregnant women who gained weight according to IOM recommendation, which classified pregnant women into four groups according to pre-pregnancy body mass index (BMI) would have better maternal and neonatal outcomes in terms of cesarean delivery, preterm birth, low birth weight, and large for gestational age, etc. However, IOM studies were conducted in westerners who are very much different from Thai women. Therefore, a study to see if IOM recommendation is applicable to pregnant Thai women is necessary.

What this study adds?

This study showed that IOM recommendation is applicable to pregnant Thai women. This mean that gestational weight gain for the betterment of pregnancy outcomes might have nothing to do with race. However, the exact or more accurate gestational weight gain for pregnant Thai women should be sought out and used as one of the indicators of wellbeing of the pregnant women and their offspring.

Potential conflicts of interest

None.

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ผลของน้ำหนักที่เพิ่มขึ้นระหว่างการตั้งครรภ์ที่ไม่เป็นไปตามคำแนะนำของ Institute of Medicine

เอกชัย อัศวนฤนาท

วัตถุประสงค์: *เพื่อเปรียบเทียบผลลัพธ์ของการตั้งครรภ์ระหว่างสตรีที่น้ำหนักเพิ่มขึ้นระหว่างการตั้งครรภ์ไม่เป็นไปตามคำแนะนำของ Institute of Medicine (IOM) กับสตรีที่มีน้ำหนักเพิ่มขึ้นระหว่างการตั้งครรภ์ตรงตามคำแนะนำของ IOM ในโรงพยาบาลเลิดสิน*

วัสดุและวิธีการ: *ได้ทำการทบทวนเวชระเบียนทั้งหมดของสตรีที่คลอดในโรงพยาบาลเลิดสินระหว่างวันที่ 1 ตุลาคม พ.ศ. 2553 ถึง 30 กันยายน พ.ศ. 2556 สตรีตั้งครรภ์จำนวน 3,683 ราย ที่เข้าเกณฑ์การคัดเลือกถูกแบ่งออกเป็น 4 กลุ่ม ตามดัชนีมวลกายก่อนการตั้งครรภ์ คือ ผอม น้ำหนักปกติ น้ำหนักเกิน และอ้วน ทำการเปรียบเทียบผลลัพธ์ของการตั้งครรภ์ระหว่างสตรีที่น้ำหนักเพิ่มขึ้นระหว่างการตั้งครรภ์ไม่เป็นไปตามคำแนะนำของ IOM กับสตรีที่มีน้ำหนักเพิ่มขึ้นระหว่างการตั้งครรภ์ตรงตามคำแนะนำของ IOM ในปัจจัยต่าง ๆ ได้แก่ การผ่าท้องทำคลอด ภาวะความดันโลหิตสูงระหว่างตั้งครรภ์ ภาวะเบาหวานระหว่างตั้งครรภ์ การคลอดก่อนกำหนด ทารกคลอดน้ำหนักต่ำกว่าเกณฑ์ ทารกน้ำหนักตัวน้อยแบบไม่สมอายุครรภ์ ทารกน้ำหนักตัวมากแบบไม่สมอายุครรภ์ และทารกอ้วนเกิน โดยใช้ logistic regression คำนวณหา odds ratios (ORs) และ 95% confidence intervals (CIs)*

ผลการศึกษา: *จากสตรีตั้งครรภ์จำนวน 3,683 ราย ในการศึกษานี้ 34.9% มีน้ำหนักเพิ่มขึ้นตรงตามคำแนะนำของ IOM 36.5% มีน้ำหนักเพิ่มขึ้นมากกว่าคำแนะนำของ IOM และ 28.7% มีน้ำหนักเพิ่มขึ้นน้อยกว่าคำแนะนำของ IOM สตรีที่มีน้ำหนักเพิ่มขึ้นมากกว่าคำแนะนำในทุกกลุ่มดัชนีมวลกายมีความเสี่ยงเพิ่มขึ้นต่อการผ่าท้องทำคลอด (ยกเว้นในกลุ่มอ้วน) ทารกอ้วนเกิน ทารกน้ำหนักตัวมากแบบไม่สมอายุครรภ์ และมีความเสี่ยงเพิ่มขึ้นต่อการคลอดก่อนกำหนด ทารกคลอดน้ำหนักต่ำกว่าเกณฑ์ (ยกเว้นในกลุ่มน้ำหนักเกิน) และทารกน้ำหนักตัวน้อยแบบไม่สมอายุครรภ์ สตรีที่มีน้ำหนักเพิ่มขึ้นน้อยกว่าคำแนะนำในทุกกลุ่มดัชนีมวลกาย มีความเสี่ยงเพิ่มขึ้นต่อการคลอดก่อนกำหนด ทารกคลอดน้ำหนักต่ำกว่าเกณฑ์ ทารกน้ำหนักตัวน้อยแบบไม่สมอายุครรภ์ และมีความเสี่ยงลดลงต่อการผ่าท้องทำคลอด ทารกที่คลอดจากสตรีที่มีน้ำหนักเพิ่มขึ้นมากกว่าคำแนะนำของ IOM ยังมีน้ำหนักตัวมากกว่าทารกที่เกิดจากสตรีที่มีน้ำหนักเพิ่มขึ้นตรงตามคำแนะนำของ IOM อย่างมีนัยสำคัญในทุกกลุ่มดัชนีมวลกาย*