Avoiding excessive pregnancy weight gain to obtain better pregnancy outcomes in Taiwan

Huann-Cheng Horng, MD[a,c,d], Ben-Shian Huang, MD[d,f], Yen-Feng Lu, MD[d,g], Wen-Hsun Chang, BS, MPH[a,b,e], Jyh-Shin Chiou, MD[d,g], Po-Lun Chang, PhD[c], Wen-Ling Lee, MD, PhD[h,i,*], Peng-Hui Wang, MD, PhD[a,d,f,j,*]

Abstract

Pregnancy weight gain may be associated with adverse pregnancy outcomes. The article aims to explore the relationship between weight change and pregnancy outcome in the Taiwanese pregnant women.

The retrospective cohort study enrolled women with vertex singleton pregnancy at University-associated Hospital between 2011 and 2014. Pregnancy weight change was separated into 3 groups, based on the Institute of Medicine (IOM) guidelines: below (n = 221); within (n = 544); and above (n = 382). Analysis of variance, χ^2 tests, generalized linear models, and logistic regression models were used for statistical comparisons.

Pregnant women with weight change above IOM guidelines had a significant increase in both maternal and perinatal complications compared with normal controls (odds ratio [OR] 1.65, 95% confidence interval [CI] 1.03–1.98; $P = .043$; OR 1.45, 95% CI 1.01–1.87; $P = .049$, respectively). This finding was not found in pregnant women with weight gain below IOM guidelines. Moreover, age (OR 1.08, 95% CI 1.02–1.15; $P = .0011$), pre-pregnancy weight (OR 1.04, 95% CI 1.01–1.09; $P = .0008$), pre-pregnancy body mass index (BMI; OR 1.15, 95% CI 1.06–1.30; $P < .0001$), weight at the time of delivery (OR 1.05, 95% CI 1.02–1.13; $P < .0001$) and BMI at the time of delivery (OR 1.15, 95% CI 1.06–1.39; $P < .0001$), all contributed to increased maternal complications but not perinatal complications, whereas parity (OR 0.23, 95% CI 0.12–0.41; $P < .0001$) and gestational age (OR 0.50, 95% CI 0.35–0.62; $P < .001$) were associated with fewer maternal complications.

Our study reconfirmed that for Taiwanese pregnant women, the approximate pregnancy weight gain recommended by IOM in 2009 was associated with the fewest maternal and perinatal complications. If approximate pregnancy weight gain cannot be attained, even less weight gain during pregnancy is still reasonable without significantly and adversely affecting maternal and perinatal outcomes in Taiwan.

Abbreviations: BMI = body mass index, CI = confidence interval, GA = gestational age, GDM = gestational diabetes mellitus, HR = hazard ratio, IOM = Institute of Medicine, NSD = normal spontaneous vaginal delivery, NTD = new Taiwan dollars, OR = odd ratio, PIH = pregnancy-induced hypertension, SGA = small-for-gestational age.

Keywords: maternal, perinatal, pregnancy, weight

1. Introduction

In 2009, the Institute of Medicine (IOM) updated the weight gain recommendations during pregnancy, ranging from 11.5 to 16 kg (from 25 to 35 lb) for women with normal weight.[1] Excessive pregnancy weight gain might increase risk of maternal and perinatal morbidity, such as gestational hypertension (pregnancy-induced hypertension: PIH),[2,3] preeclampsia,[2,4,5] cesarean delivery,[2,6] macrosomia,[2,7–9] low Apgar scores,[6] hypoglycemia,[6,7] admission to the neonatal intensive care unit,[6] prolonged hospital stays of neonates,[6] and childhood obesity.[9] In addition to this, excessive pregnancy weight gain also increases

the risk of gestational diabetes mellitus (GDM),[10] resulting in deleterious effect on the pregnancy outcome.[10–13] Therefore, avoiding excessive pregnancy weight gain may be a good solution to reduce GDM.[12]

Obesity also shows a negative impact on the hemodynamic stability in pregnant women. The hemodynamic changes in obese pregnant women include higher arterial blood pressure, hemoconcentration, and altered cardiac function, resulting in prevalent hypertensive disorders,[14] and subsequently contributing to poor maternal and perinatal outcomes.[15–17] A recent nationwide population-based retrospective cohort study in Taiwan showed that obesity (hazard ratio [HR] 7.21, 95% confidence interval [CI] 1.58–32.84) was an independent risk factor for the development of intracranial hemorrhage later among pregnant women.[15] In addition, these hypertensive disorders during pregnancy also increased the risk of placental abruption, small-for-gestational age (SGA) newborns, lower Apgar scores, and perinatal mortality.[18–20]

The previous Taiwan's experience has shown that the total pregnancy weight gain should be <11.5 kg among women with normal weight and within 10 kg for women with overweight, because the risk of macrosomia might increase 9-fold (odds ratio [OR] 9.63, 95% CI 1.76–52.74),[21] which subsequently contributed to an increased risk for adverse maternal and neonatal outcome.[21–24] The previous study by D'Angelo et al have suggested that women may benefit from targeted interventions during the preconception and conception periods, which may promote positive maternal and infant health behaviors, experiences, and reproductive outcomes.[25] On the other hand, pregnant women with gestational gain below the IOM guidelines might be at higher risk for placental abruption, SGA newborns, and low birth weight neonates.[23,26] However, the value of preventive strategy for adequate pregnancy weight gain in Taiwan is still unclear. Thus, we conducted this retrospective cohort study, which enrolled healthy mothers who participated in an individual 15-minute dietary and lifestyle education program in one of the medical school-associated hospitals in Taiwan.

2. Materials and methods

In this retrospective cohort study, we provided health education on various prenatal topics and subsequently monitored body weight gain during the whole course of their pregnancy. The study was conducted over a 4-year period from January 2011 through December 2014 in pregnant women at the National Yang Ming University Hospital in Taiwan. Approval for the study was obtained from the hospital's ethics committee, and informed consent was obtained from all patients (YMUH Institutional Review Board 2010A029). All pregnant women who began prenatal care (the first antenatal visit) at our hospital were screened to determine whether they were eligible for the study. In addition to the perinatal care program provided by Taiwan Health Promotion Administration, Ministry of Health and Welfare, all pregnant women participated in an individual 15-minute dietary and lifestyle education program conducted by physicians and nurse staff at every clinic visit. This program was a free couple (pregnant women and their spouses)-specific dietary and lifestyle intervention, which differed from the traditional education programs for general prenatal topics during pregnancy (group containing 10–15 couples). The program consisted of a total of 10 classes, 3 of them in the first 20 weeks of gestation, 4 between 20 and 30 weeks and 4 after the 30 weeks of gestation. The contents of the classes focused on the dietary education,

including essential nutrition during pregnancy, such as essential amino acids, ferrum, folic acid, and trace elements supplementation, and calorie calculation of food, and life-style education, including exercise and rest. Body weight was recorded every week. This mandatory procedure marked the official beginning of prenatal care in our hospital. Pre-pregnancy weight, height, and body mass index (BMI, weight (kg)/height^2 (m)) were based on health care provider assessment, which was documented at the first antenatal visit. Total weight gained during pregnancy, including the patient's BMI, was determined.

Inclusion criteria included singleton vertex births, healthy pregnant women with normal body weight who received regular prenatal care and delivered at our hospital, signed informed consent by the patient. Normal weight was calculated as a pre-pregnancy BMI between 18.5 and 24.9.

Exclusion criteria included pregnant women who had fetal anomalies, diabetes mellitus, chronic hypertension, preterm delivery of less than 34 weeks, which might underestimate the influence on changes in maternal weight, incomplete data on other variables of interest, and elective cesarean delivery due to malpresentation, placenta previa, previous cesarean delivery or a history of uterine surgery. The flow chart that allocated patients into different groups is shown in Figure 1.

Pregnancy weight gain was based on the IOM guidelines and was separated into 3 groups: below IOM guidelines (<11.5 kg); within IOM guidelines (11.5–16 kg, normal controls); and above IOM guidelines (>16 kg).

The following adverse maternal and perinatal outcomes were examined: GDM, preeclampsia, PIH, abnormal labor, postpartum hemorrhage, fourth-degree laceration, cesarean delivery, macrosomia (birth weight of 4500 g or more), nonreassuring fetal status, Apgar score of <7 at 1 minute, meconium aspiration, preterm births, and low birth weight (birth weight 2500 g or less). Medical costs for hospitalization during delivery were recorded and analyzed. Abnormal labor included prolongation, protraction, and arrest disorders. Classification of the fetal heart rate (FHR) tracings was based on the 3-tier classification system according to the American College of Obstetricians and Gynecologists (ACOG).[27] Category 2 tracings were considered indeterminate. This category required evaluation and surveillance and possibly other tests to ensure fetal health. Category 3 tracings were considered abnormal and required prompt evaluation. Vaginal delivery was categorized as normal spontaneous vaginal delivery (NSD) or operative vaginal delivery with vacuum and/or forceps (instrument delivery).

We used SAS version 9.2 (SAS institute Inc, Cary, NC) for all analyses to account for the complex sample design. Descriptive statistics are presented as the means and standard deviation or percentages. Pearson's chi-square tests were used for categorical
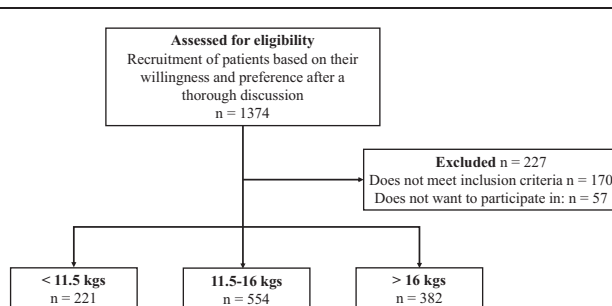

Figure 1. Flow chart of group allocation.

variables. Medical cost comparisons of maternal and perinatal outcomes were analyzed by the generalized linear model. The risks of maternal and perinatal complications were presented as ORs using logistic regression according to the following groups: pregnancy weight gain, pre-pregnancy weight, weight at delivery, weight change, pre-pregnancy BMI, BMI at delivery, and BMI change. A P value of less than .05 was regarded as statistically significant.

3. Results

Of the 1147 pregnant women who met study criteria, 19.27% had a pregnant weight gain of less than 11.5 kg (below IOM guidelines), 47.43% had a pregnancy weight gain within 11.5 to 16 kg (within IOM guidelines), and 33.30% had a pregnancy weight gain of more than 16 kg (above IOM guidelines). Among the 3 groups, there were statistically significant differences in pre-pregnancy weight, weight at time of delivery, BMI at time of delivery, maternal and perinatal complications, and perinatal birth weight (Table 1). Women with weight gain above IOM guidelines appeared to, be heavier in weight at the time of delivery have higher BMI at time of delivery, have higher maternal and perinatal complication rates. Women with weight gain below IOM guidelines exhibited heavier weight during the pre-pregnancy period, but they exhibited lighter weight at time of delivery, lower BMI at the time of delivery, and low birth weight in newborns. However, in the comparisons of the 3 groups, there was no statistic significance (Table 1).

Pregnancy outcome in the women with different weight gains is listed in Table 2. Consistent with the increased risk of maternal complications in women with weight gain above IOM guidelines, these pregnant women had a higher risk of GDM, dysfunction labor, and cesarean delivery. In addition, women with weight gain above IOM guidelines were at increased risk of macrosomia and meconium aspiration. However, among the 3 groups, there was no significant difference in PIH, preeclampsia, postpartum hemorrhage, fourth-degree laceration, macrosomia, category 2/3

FHR tracings, Apgar scores of <7 at 1 minute, preterm births, and low-birth weight (Table 2).

The generalized linear regression model revealed that the medical costs increased significantly with the following factors: age (P=.0338), pregnancy weight gain above IOM guidelines (P=.0079), GDM (P=.0109), PIH (P < .0001), preeclampsia (P=.0152), postpartum hemorrhage (P<.0001), cesarean delivery (P<.0001), macrosomia (P=.0062), category 2/3 FHR tracings (P<.0021), meconium aspiration (P=.0048), and preterm births (P=.0034) (Table 3). Gestational age (GA), pregnancy weight gain below IOM guidelines, parity, fourth-degree laceration, Apgar scores of <7 at 1 minute, and low birth weight were not associated with increased medical costs (Table 3).

In Table 4, the significant predictors of adverse maternal and perinatal outcomes included pre-pregnancy weight, weight at the time of delivery, pre-pregnancy BMI, BMI at the time of delivery and changes in BMI according to the logistic regression model. Our results demonstrated that the highest accuracy rate in forecasting maternal complications was 79.0% in BMI at the time of delivery. The highest rate in forecasting neonatal complications was 65.2% in weight at the time of delivery. Moreover, analysis of predictors of maternal complications in pregnancy weight gain revealed that pregnancy weight gain above IOM guidelines (OR 1.65, 95% CI 1.03–1.98) and age (OR 1.08, 95% CI 1.02–1.15) were associated with more maternal complications, whereas parity (OR 0.23, 95% CI 0.12–0.41) and GA (OR 0.50, 95% CI 0.35–0.62) were associated with lower maternal complications. In addition, analysis of predictors of adverse perinatal outcomes revealed that pregnancy weight gain above IOM guidelines (OR 1.45, 95% CI 1.01–1.87), non-NSD (OR 2.85, 95% CI 1.45–3.56) and age (OR 1.06, 95% CI 1.01–1.12) were associated with more perinatal complications, while parity (OR 0.66, 95% CI 0.45–0.91) and GA (OR 0.65, 95% CI 0.56–0.77) were associated lower perinatal outcomes (Table 4).

The operative vaginal delivery (instrument delivery) rate increased in women with pregnancy weight gain above IOM guidelines

Table 1

Clinical characteristics.

	Total n = 1147	<11.5 kg (Gr. 1) n = 221 (19.27%)	11.5–16 kg (Gr. 2) n = 544 (47.43%)	>16 kg (Gr. 3) n = 382 (33.30%)
Age	29.02 ± 4.36	29.38 ± 4.41	29.01 ± 4.59	28.30 ± 4.11
Pre-pregnancy weight, kg*	53.49 ± 8.13	56.20 ± 10.06	52.92 ± 7.72	53.12 ± 8.08
Weight at time of delivery, kg†	67.18 ± 9.20	64.40 ± 9.23	65.33 ± 7.69	71.52 ± 9.15
Pre-pregnancy BMI	21.08 ± 3.06	22.02 ± 4.08	20.83 ± 2.92	20.82 ± 2.71
BMI at time of delivery‡	26.52 ± 3.45	24.52 ± 4.01	25.88 ± 3.52	27.95 ± 3.34
Cost during hospitalization (NTD)§	24488.61 ± 3721.65	23924 ± 3166.82	24433.67 ± 3514.82	24981 ± 4099.12
Maternal complication rate, %‖	0.23 ± 0.56	0.16 ± 0.51	0.13 ± 0.53	0.33 ± 0.63
Perinatal complication rate, %¶	0.20 ± 0.52	0.21 ± 0.41	0.16 ± 0.48	0.26 ± 0.52
Birth weight, g#	3152.61 ± 369.88	3032.87 ± 368.35	3118.67 ± 366.68	3234.22 ± 373.43
Gestational age, wk	38.41 ± 1.17	38.13 ± 1.09	38.41 ± 1.15	38.58 ± 1.21
Apgar score at 1 minute	7.90 ± 0.32	7.96 ± 0.26	7.94 ± 0.28	7.88 ± 0.39
Apgar score at 5 minute	8.96 ± 0.20	8.97 ± 0.11	8.96 ± 0.23	8.95 ± 0.26

* Gr. 1 vs Gr. 2, P=.027; Gr. 1 vs Gr. 3, P=.034; Gr. 2 vs Gr. 3, P=.463.
† Gr. 1 vs Gr. 2, P=.275; Gr. 1 vs Gr. 3, P=.021; Gr. 2 vs Gr. 3, P=.043.
‡ Gr. 1 vs Gr. 2, P=.687; Gr. 1 vs Gr. 3, P=.046; Gr. 2 vs Gr. 3, P=.057.
§ Gr. 1 vs Gr. 2, P=.485; Gr. 1 vs Gr. 3, P=.107; Gr. 2 vs Gr. 3, P=.723.
‖ Gr. 1 vs Gr. 2, P=.332; Gr. 1 vs Gr. 3, P=.035; Gr. 2 vs Gr. 3, P=.026.
¶ Gr. 1 vs Gr. 2, P=.088; Gr. 1 vs Gr. 3, P=.062; Gr. 2 vs Gr. 3, P=.041.
# Gr. 1 vs Gr. 2, P=.142; Gr. 1 vs Gr. 3, P=.028; Gr. 2 vs Gr. 3, P=.201.
Gr. = group, BMI = body mass index (kg/m²), NTD = new Taiwan Dollars (1/33 US dollars).
Data are presented as mean ± standard deviation (SD).

Table 2

Clinical characteristics and adverse outcomes associated with pregnancy weight gain.

	Total n=1147 (%)	<11.5 kg n=221 (%)	11.5–16 kg n=544 (%)	>16 kg n=382 (%)	P
Parity					<.0001
0	540 (47.08)	71 (32.13)	229 (42.10)	240 (62.83)	
1 or more	607 (52.92)	150 (67.87)	315 (57.90)	142 (37.17)	
Maternal complications					
GDM					
No	1133 (98.78)	217 (98.19)	543 (99.82)	373 (97.64)	.008
Yes	14 (1.22)	4 (1.81)	1 (0.18)	9 (2.36)	
PIH					
No	1125 (98.08)	216 (97.74)	536 (98.52)	373 (97.64)	.575
Yes	22 (1.92)	5 (2.09)	8 (1.48)	9 (2.36)	
Preeclampsia					
No	1133 (98.78)	217 (98.19)	541 (99.45)	375 (98.17)	.146
Yes	14 (1.22)	4 (1.81)	3 (0.55)	7 (1.83)	
Dysfunction labor*					
No	1113 (97.04)	220 (99.54)	533 (97.98)	360 (94.24)	<.0001
Yes	34 (2.96)	1 (0.46)	11 (2.02)	22 (5.76)	
PPH					
No	1138 (99.21)	220 (99.55)	541 (99.45)	377 (98.69)	.360
Yes	9 (0.79)	1 (0.45)	3 (0.55)	5 (1.31)	
Fourth-degree laceration					
No	1123 (97.91)	217 (98.19)	537 (98.71)	369 (96.60)	.082
Yes	24 (2.09)	4 (1.81)	7 (1.29)	13 (3.40)	
Cesarean delivery					
No	107 8 (93.98)	217 (98.19)	523 (96.14)	338 (88.48)	<.0001
Yes	69 (6.02)	4 (1.81)	21 (3.86)	44 (11.52)	
Perinatal complications					
Macrosomia					
No	1134 (98.87)	220 (99.55)	540 (99.26)	374 (98.17)	.089
Yes	13 (1.13)	1 (0.45)	4 (0.74)	8 (2.09)	
Category 2/3 FHR tracings					
No	1132 (98.69)	219 (99.10)	536 (98.53)	377 (98.69)	.823
Yes	15 (1.31)	2 (0.09)	8 (1.47)	5 (1.31)	
Apgar score <7†					
No	1144 (99.74)	221 (100.00)	543 (99.82)	380 (99.48)	.425
Yes	3 (0.26)	0 (0.00)	1 (0.18)	2 (0.52)	
Meconium aspiration					
No	1035 (90.24)	206 (93.21)	505 (92.91)	324 (84.82)	<.0001
Yes	112 (9.76)	15 (6.79)	39 (7.09)	58 (15.18)	
Preterm birth					
No	1089 (94.94)	204 (92.31)	517 (95.04)	368 (96.34)	.093
Yes	58 (5.06)	17 (7.69)	27 (4.96)	14 (3.66)	
Low birth weight					
No	1118 (97.47)	182 (95.29)	530 (97.43)	376 (98.43)	.168
Yes	29 (2.53)	9 (4.71)	14 (2.57)	6 (1.57)	

FHR = fetal heart rate, GDM = gestational diabetes, PIH = pregnancy-induced hypertension, PPH = postpartum hemorrhage.

* Dysfunction labor = prolongation, protraction, and arrest disorders.

† Apgar score at 1 minute.

compared with the other 2 groups (Table 5). Moreover, greater medical expenses were needed for operative vaginal delivery compared with NSD (new Taiwan dollars [NTD] 23359.98± 614.21 vs 22740.40±779.33, P=.0124). However, there was no significant difference in clinical adverse outcomes between operative vaginal delivery and NSD groups (data not shown).

4. Discussion

Through adequate weight control, pregnant women with pregnancy weight gain within IOM guidelines have fewer maternal complications and fewer perinatal complications compared with women with pregnancy weight gain above or below IOM guidelines.[21,22,26] However, maintaining appropri-ate maternal weight may not be easy, as demonstrated by the frequency of excessive pregnancy weight gain. It was previously demonstrated by Johnson et al that nearly three-fourths of pregnant women exhibited weight gain above IOM guidelines.[2] Our study demonstrated a feasible modality of achieving adequate weight control using individual 15-minutes dietary and lifestyle education counseling. Of 1147 pregnancies, nearly half of the pregnant women were able to maintain their body weight gain within IOM guidelines.

Although there is ample evidence that pregnant weight gain is associated with adverse maternal and neonatal outcomes, the subjects in these studies were overweight or obese for the most part.[2–8] The strength of our study is that the pre-pregnancy body weight in the study population is within normal limits.

Table 3

Medical cost comparison of clinical characteristics and adverse outcomes.

		Cost*	P
Age		17.44	.0338
GA, wk		19.11	.6885
Weight gains			
<11.5 kg		−32.91	.3271
11.5–16 kg	(ref: 24433.67 ± 3514.82)		
>16 kg		301.06	.0079
Parity			
0	(ref: 24525.20 ± 3955.22)		
1 or more		−108.45	.2230
Labor			
NSD	(ref: 24411.37 ± 3668.85)		
Non-NSD		9510.33	<.0001
Maternal complication			
GDM	No (ref: 24468.25 ± 3814.28)		
	Yes	1144.52	0.0109
PIH	No (ref: 24424.74 ± 3642.77)		
	Yes	2081.13	<.0001
Preeclampsia	No (ref: 24432.33 ± 3730.37)		
	Yes	1083.82	.0152
PPH	No (ref: 24480.92 ± 3635.17)		
	Yes	3318.48	<.0001
Fourth-degree laceration	No (ref: 24468.82 ± 3714.56)		
	Yes	9.77	.9714
Cesarean delivery	No (ref: 24434.52 ± 4198.63)		
	Yes	8775.72	<0.0001
Perinatal complication			
Macrosomia	No (ref: 24430.67 ± 3715.41)		
	Yes	1321.42	.0062
Category 2/3 FHR tracings	No (ref: 24465.29 ± 3842.12)		
	Yes	1802.77	.0021
Apgar score <7[†]	No (ref: 24479.67 ± 3728.22)		
	Yes	988.49	.1941
Meconium aspiration	No (ref: 24403.37 ± 3692.18)		
	Yes	1387.55	.0048
Preterm birth	No (ref: 24458.41 ± 3724.24)		
	Yes	1554.69	.0034
Low birth weight	No (ref: 24465.22 ± 3697.05)		
	Yes		.168

FHR = fetal heart rate, GA = gestational age, GDM = gestational diabetes, NSD = normal spontaneous vaginal delivery, PIH = pregnancy-induced hypertension, PPH = postpartum hemorrhage, ref = reference.
* Cost (∘ β) = medical cost in New Taiwan dollars (1/33 US dollars); ref = reference.
[†] Apgar score at 1 minute.

Table 4

Predicting model using logistic regression by maternal weight and body mass index.

	Maternal complications				Perinatal complications			
	OR	95% CI	P	C	OR	95% CI	P	C
Pregnancy weight gain				0.772				0.650
<11.5 kg	0.74	(0.58, 1.22)	.2612		0.92	(0.68, 1.42)	.5609	
11.5–16 kg (ref)	1							
>16 kg	1.65	(1.03, 1.98)	.0433		1.45	(1.01, 1.87)	.0493	
Parity								
0 (ref)	1							
1 or more	0.23	(0.12, 0.41)	<.0001		0.66	(0.45, 0.91)	.0239	
Labor								
NSD (ref)	1							
Non-NSD	1.34	(0.87, 1.65)	.8941		2.85	(1.45, 3.56)	.0024	
Age	1.08	(1.02, 1.15)	.0011		1.06	(1.01, 1.12)	.0067	
Gestational weeks	0.50	(0.35, 0.62)	<.0001		0.65	(0.56, 0.77)	<.0001	
Pre-pregnancy weight	1.04	(1.01, 1.09)	.0008	0.764	1.04	(1.01, 1.15)	.0127	0.644
Weight at time of delivery	1.05	(1.02, 1.13)	<.0001	0.775	1.05	(1.01, 1.20)	.0017	0.652
Weight change	5.91	(0.88, 6.85)	.0783	0.754	1.92	(0.84, 3.56)	.4774	0.644
Pre-pregnancy BMI	1.15	(1.06, 1.30)	<.0001	0.777	1.09	(1.03, 1.26)	.0044	0.648
BMI at time of delivery	1.15	(1.06, 1.39)	<.0001	0.790	1.11	(1.05, 1.24)	.0004	0.649
BMI change	1.22	(1.08, 1.56)	.0004	0.764	1.11	(1.03, 1.31)	.0414	0.642

NSD = normal spontaneous vaginal delivery, OR = odds ratio, 95% CI = 95% confidence interval, ref = reference, BMI = body mass index (kg/m²), C = accuracy rate.

Table 5

Risk of instrument delivery associated with pregnancy weight gain by Pearson's chi-square test.

	<11.5 kg n=217 (%)	11.5–16 kg n=523 (%)	>16 kg n=338 (%)	*P*
NSD	176 (81.11)	440 (84.13)	235 (69.53)	<.0001
Instrument delivery	41 (18.89)	83 (15.87)	103 (30.47)	

NSD = normal spontaneous vaginal delivery, instrument delivery = an assisted vaginal delivery by vacuum or forceps.

This study population also reduced the impact of pre-pregnancy obesity on the outcomes. The results of our study showed that weight gain above IOM guidelines significantly increased not only maternal and perinatal complications but also medical costs. Our study shows the importance of active intervention not only in counseling to control overweight or obesity but also in women exhibiting a normal weight during pregnancy.[28] Indeed, adequate weight control during pregnancy significantly reduces medical costs and may also lower the risk of persistent postpartum obese diathesis.[29] Interestingly, 1 study reported that maternal pregnancy weight gain was also associated with offspring childhood obesity during a 3-year follow-up period.[9] Thus, it is important for both normal and obese pregnant women to conduct preconception counseling and exhibit optimal weight gain to reduce maternal and perinatal complications and medical costs.[30]

In our current study, women with pregnancy weight gain above IOM guidelines presented with similar PIH and pre-eclampsia as those within and below IOM guidelines. The possible reason is unknown, but normal weight before pregnancy might be one of the causes.

Low Apgar scores are more frequent in neonates of pregnant women with weight gain above IOM guidelines than in those of pregnant women with weight gain within IOM guidelines (OR 1.33, 95% CI 1.01–1.76).[6] In our study, newborns of women with weight gain above IOM guidelines had lower Apgar scores at 1 minute but did not have lower Apgar scores at 5 minutes. The possible reason is unknown, but lower Apgar scores were correlated with more category 2/3 FHR tracings that revealed fetal distress and abnormal labor in women with pregnancy weight gain above IOM guidelines; these events subsequently resulted in the frequent use of instrument and caesarean deliveries. The perinatal complications are likely to be due to multiple mechanisms and many unknown or subclinical metabolic changes in these pregnant women with weight gain above IOM guidelines are always present.[6] Stotland's study demonstrated an increased risk of neonatal hypoglycemia with excessive gestational gain.[6] Obese women had signs of adipocyte recruitment and maintenance of adiponectin levels, significantly contributing to gestation insulin resistance, even though these women all remained normoglycemic.[31]

Using the logistic regression model, our results demonstrated that pregnancy weight gain above IOM guidelines might increase both maternal (OR 1.65, 95% CI 1.03–1.98) and perinatal complications (OR 1.45, 95% CI 1.01–1.87). After further analysis, we found that the highest accuracy rate in forecasting maternal and perinatal complications was BMI at the time of delivery (79.0%) and weight at the time of delivery (65.2%), respectively. Although there are different definitions in weight and BMI, both suggest that the absolute weight status, even according to BMI or final body weight at the time of delivery, is of paramount importance, suggesting that targeted intervention in weight control during the course of pregnancy is useful. Recent studies have shown that interventions in body weight of women who plan to get pregnant might further decrease the incidence of adverse outcomes in pregnancy.[32–34] Many studies also showed that targeted efforts and effective interventions during pregnancy can improve weight gain trajectories and overall health.[35–39]

This study has some limitations that might affect the medical costs and adverse outcomes that occur with maternal pregnant weight gain. First, we did not recruit underweight, overweight or obese women before conception. However, this aspect is also the strength of our study.

Second, the medical expenditure was limited only to that at the time of delivery. The costs of the preventive strategy used in the current study to educate and care the women to maintain adequate weight control were not included in the final calculation of the expenses. If these expenses were taken into consideration, the medical costs (the concealed cost was NTD 3000 in each time) were even higher. However, we believed that these concealed costs might be compensated by the concealed costs of complications. The women with instrument-assisted delivery might have a higher risk of the development of pelvic organ prolapse and/or urinary incontinence than those with NSD.[40,41] Moreover, we did not compared the women enrolled in our preventive strategy with those who took only part in traditional perinatal care program.

Third, the compliance of the subjects in our current study was not evaluated. It is highly possible that the compliance of pregnant women differed. Some pregnant women might carry a lot of misbeliefs and did not follow the suggestions offered by this specific dietary and lifestyle intervention program. As shown in the current study, there were still one-third of study subjects (33.3%) who had an excess pregnancy weight gain, suggesting that some women still believed that their babies would be stronger if they were not concerned with the pregnancy weight.

Fourth, the study population was relatively small compared with previous reports, which enrolled 312,412 and 292,568 births, respectively[42,43] Moreover previous studies clearly showed that different races might impact obesity-related neonatal complications of pregnancy. Obese Caucasian women and it younger population had a higher risk to have macrosomic babies and infant complications than obese African-American women and it younger population did, respectively.[42,44] Dr Liu's report showed both excessive or insufficient maternal weight gain were associated with increased risks for adverse pregnancy outcomes in Chinese women.[43] However, the above-mentioned study population was based on the "Perinatal Health Care Surveillance System," therefore the relatively heterogeneous population cannot be totally avoided.[43] In addition, the study period was relatively long and medical care might be varied greatly during this time. On the contrary, our study was carried out in a short time and in a population that inhabits a country area free of environmental pollution. In addition, all women received a similar prenatal and perinatal care based on the Taiwan's National Health Insurance program[45,46] along with the individual 15-minute dietary and lifestyle education program.

Fifth, adequate nutritional support for pregnant women is an important issue. Adequate protein intake helps pregnant women to maintain their health and performance, but this also affects fetal growth and minimizes adverse outcomes.[47] In addition to this, it is also well-known that specific diets, such as a plant-based protein diet, might fail to provide adequate amounts of essential amino acids.[48,49] Moreover, dietary food intake might vary within a population, according with race or social background, for example, regardless of pregnancy weight gain status. In the current study, the detailed information of food intake was not recorded. Nevertheless, the study subjects all lived in the same area pollution-free country site, were all Taiwanese women, presented homogeneous social background and, all enrolled the same Taiwan's healthcare system thus suggesting that the consideration of the potential bias can be neglected.

Finally, in the current study, medical costs were recorded as a whole without independently accounting for the maternal and neonatal components. Based on the fixed payment system for the labor process, which was guided by Taiwan Diagnosis Related Groups,[50,51] regardless of women treated with operative delivery (including caesarean section and instrument-assisted vaginal delivery) or vaginal delivery by Taiwan National Health Insurance Administration, Ministry of Health and Welfare, the cost reduction may be underestimated in the present study. It is clearly shown that costs of instrumental and caesarean deliveries were significantly higher than those of vaginal delivery without spontaneous complications (baseline cost), as shown in Table 3. The results presented in Table 5 also show that women with pregnancy weight gain above IOM guidelines (>16 kg) had a significantly increased risk of instrumental delivery.

In conclusion, consistent with previous reports showing the worse outcome in pregnant women with significantly increased gestational weight gains,[23,24,52,53] this study highlights the prospective role of approximate weight gain or even less weight gain during pregnancy, which could lower maternal and neonatal complications in the Taiwanese pregnant women, although the recommendation of the later (gestational weight gain below IOM guidelines) is still conflicted.[54] Health education on various prenatal topics and efforts to decrease body weight gain during pregnancy would be a better strategy to minimize the risk of both maternal and neonatal complications.

Acknowledgments

References

[1] Rasmussen KM, Yaktine AL. The National Academies Collection: Reports funded by National Institutes of Health. Weight Gain During Pregnancy: Reexamining the Guidelines Institute of Medicine, National Academies Press (US), National Academy of Sciences, Washington, DC:2009.

[2] Johnson J, Clifton RG, Roberts JM, et al. Pregnancy outcomes with weight gain above or below the 2009 Institute of Medicine guidelines. Obstet Gynecol 2013;121:969–75.

[3] Crane JM, White J, Murphy P, et al. The effect of gestational weight gain by body mass index on maternal and neonatal outcomes. J Obstet Gynaecol Canada 2009;31:28–35.

[4] de la Torre L, Flick AA, Istwan N, et al. The effect of new antepartum weight gain guidelines and prepregnancy body mass index on the development of pregnancy-related hypertension. Am J Perinatol 2011;28:285–92.

[5] Fortner RT, Pekow P, Solomon CG, et al. Prepregnancy body mass index, gestational weight gain, and risk of hypertensive pregnancy among Latina women. Am J Obstet Gynecol 2009;200:167.e161–7.

[6] Stotland NE, Cheng YW, Hopkins LM, et al. Gestational weight gain and adverse neonatal outcome among term infants. Obstet Gynecol 2006;108(3 pt 1):635–43.

[7] Hedderson MM, Weiss NS, Sacks DA, et al. Pregnancy weight gain and risk of neonatal complications: macrosomia, hypoglycemia, and hyperbilirubinemia. Obstet Gynecol 2006;108:1153–61.

[8] Swank ML, Caughey AB, Farinelli CK, et al. The impact of change in pregnancy body mass index on macrosomia. Obesity (Silver Spring) 2014;22:1997–2002.

[9] Oken E, Taveras EM, Kleinman KP, et al. Gestational weight gain and child adiposity at age 3 years. Am J Obstet Gynecol 2007;196:322.e321–8.

[10] Galtier-Dereure F, Boegner C, Bringer J. Obesity and pregnancy: complications and cost. Am J Clinic Nutr 2000;71(5 suppl):1242S–8S.

[11] Tryggvadottir EA, Medek H, Birgisdottir BE, et al. Association between healthy maternal dietary pattern and risk for gestational diabetes mellitus. Eur J Clinic Nutr 2016;70:237–42.

[12] Brunner S, Stecher L, Ziebarth S, et al. Excessive gestational weight gain prior to glucose screening and the risk of gestational diabetes: a meta-analysis. Diabetologia 2015;58:2229–37.

[13] Landon MB, Osei K, Platt M, et al. The differential effects of body fat distribution on insulin and glucose metabolism during pregnancy. Am J Obstet Gynecol 1994;171:875–84.

[14] Tomoda S, Tamura T, Sudo Y, et al. Effects of obesity on pregnant women: maternal hemodynamic change. Am J Perinatol 1996;13:73–8.

[15] Lin LT, Tsui KH, Cheng JT, et al. Increased risk of intracranial hemorrhage in patients with pregnancy-induced hypertension: a nationwide population-based retrospective cohort study. Medicine (Baltimore) 2016;95:e3732.

[16] Leaños-Miranda A, Méndez-Aguilar F, Ramírez-Valenzuela KL, et al. Circulating angiogenic factors are related to the severity of gestational hypertension and preeclampsia, and their adverse outcomes. Medicine (Baltimore) 2017;96:e6005.

[17] Lei J, Li Y, Zhang S, et al. The prognostic role of angiotensin II type 1 receptor autoantibody in non-gravid hypertension and pre-eclampsia: a meta-analysis and our studies. Medicine (Baltimore) 2016;95:e3494.

[18] Visentin S, Londero AP, Camerin M, et al. A possible new approach in the prediction of late gestational hypertension: the role of the fetal aortic intima-media thickness. Medicine (Baltimore) 2017;96:e5515.

[19] Wang C, Geng H, Liu W, et al. Prenatal, perinatal, and postnatal factors associated with autism: a meta-analysis. Medicine (Baltimore) 2017;96:e6696.

[20] Wang PH, Yang MJ, Chen CY, et al. Endothelial cell dysfunction and preeclampsia. J Chin Med Assoc 2015;78:321–2.

[21] Tsai YL, Chong KM, Seow KM. Following the 2009 American Institute of Medicine recommendations for normal body mass index and overweight women led to an increased risk of fetal macrosomia among Taiwanese women. Taiwan J Obstet Gynecol 2013;52:341–6.

[22] Hsieh WC, Liang CC, Wu D, et al. Prevalence and contributing factors of severe perineal damage following episiotomy-assisted vaginal delivery. Taiwan J Obstet Gynecol 2014;53:481–5.

[23] Hung TH, Chen SF, Hsu JJ, et al. Gestational weight gain and risks for adverse perinatal outcomes: A retrospective cohort study based on the 2009 Institute of Medicine guidelines. Taiwan J Obstet Gynecol 2015;54:421–5.

[24] Hung TH, Hsieh TT. Pregestational body mass index, gestational weight gain, and risks for adverse pregnancy outcomes among Taiwanese women: a retrospective cohort study. Taiwan J Obstet Gynecol 2016;55:575–81.

[25] D'Angelo D, Williams L, Morrow B, et al. Preconception and interconception health status of women who recently gave birth to a live-born infant—Pregnancy Risk Assessment Monitoring System (PRAMS), United States, 26 reporting areas, 2004. MMWR Surveill Summ 2007;56:1–35.

[26] Tsai YL, Chen LC, Seow KM, et al. The recommendations of the American Institute of Medicine (IOM) for normal and underweight women to reduce the risk of low birth weight. Taiwan J Obstet Gynecol 2015;54:1–7.

[27] American College of Obstetricians and GynecologistsACOG Practice Bulletin No. 106: Intrapartum fetal heart rate monitoring: nomenclature, interpretation, and general management principles. Obstet Gynecol 2009;114:192–202.

[28] Guelinckx I, Devlieger R, Beckers K, et al. Maternal obesity: pregnancy complications, gestational weight gain and nutrition. Obes Rev 2008;9:140–50.

[29] Olson CM, Strawderman MS, Hinton PS, et al. Gestational weight gain and postpartum behaviors associated with weight change from early pregnancy to 1 y postpartum. Int J Obes Relat Metab Disord 2003;27:117–27.

[30] Cedergren MI. Maternal morbid obesity and the risk of adverse pregnancy outcome. Obstet Gynecol 2004;103:219–24.

[31] Svensson H, Wetterling L, Bosaeus M, et al. Body fat mass and the proportion of very large adipocytes in pregnant women are associated with gestational insulin resistance. Int J Obes (Lond) 2016;40:646–53.

[32] Young OM, Twedt R, Catov JM. Pre-pregnancy maternal obesity and the risk of preterm preeclampsia in the American primigravida. Obesity (Silver Spring) 2016;24:1226–9.

[33] Cnattingius S, Villamor E. Weight change between successive pregnancies and risks of stillbirth and infant mortality: a nationwide cohort study. Lancet 2016;387:558–65.

[34] Berenson AB, Pohlmeier AM, Laz TH, et al. Obesity risk knowledge, weight misperception, and diet and health-related attitudes among women intending to become pregnant. J Acad Nutr Diet 2016;116:69–75.

[35] Magriples U, Boynton MH, Kershaw TS, et al. The impact of group prenatal care on pregnancy and postpartum weight trajectories. Am J Obstet Gynecol 2015;213:688.e1–e9.

[36] Lilley S, Anderson K, Benbow E. Choose to change maternity weight management pilot. Pregnancy Hypertens 2014;4:232.

[37] Haby K, Glantz A, Hanas R, et al. Mighty Mums—an antenatal health care intervention can reduce gestational weight gain in women with obesity. Midwifery 2015;31:685–92.

[38] Bogaerts A, Ameye L, Martens E, et al. Weight loss in obese pregnant women and risk for adverse perinatal outcomes. Obstet Gynecol 2015;125:566–75.

[39] Cox Bauer CM, Bernhard KA, Greer DM, et al. Maternal and neonatal outcomes in obese women who lose weight during pregnancy. J Perinatol 2016;36:278–83.

[40] Horng HC, Chen YJ, Wang PH. Urinary incontinence: is vaginal delivery a cause? J Chin Med Assoc 2017;80:465–6.

[41] Wang PH, Ho CH, Chen YJ, et al. Highlights from the 2015 annual meeting and first international congress of the Taiwan Association of Gynecology. Taiwan J Obstet Gynecol 2015;54:803–5.

[42] Marshall NE, Guild C, Cheng YW, et al. Racial disparities in pregnancy outcomes in obese women. J Matern Fetal Neonatal Med 2014;27:122–6.

[43] Liu Y, Dai W, Dai X, et al. Prepregnancy body mass index and gestational weight gain with the outcome of pregnancy: a 13-year study of 292,568 cases in China. Arch Gynecol Obstet 2012;286:905–11.

[44] Truong YN, Yee LM, Caughey AB, et al. Weight gain in pregnancy: does the Institute of Medicine have it right? Am J Obstet Gynecol 2015;212:362.e1–8.

[45] Lin LT, Wang PH, Tsui KH, et al. Increased risk of systemic lupus erythematosus in pregnancy-induced hypertension: a nationwide population-based retrospective cohort study. Medicine (Baltimore) 2016;95:e4407.

[46] Lee WL, Chang WH, Wang KC, et al. The risk of epithelial ovarian cancer of women with endometriosis may be varied greatly if diagnostic criteria are different: a nationwide population-based cohort study. Medicine (Baltimore) 2015;94:e1633.

[47] Li YT, Lee WL, Wang PH. Does vitamin supplement use reduce serum levels of some heavy metals and/or trace inorganic elements in pregnant women? J Chin Med Assoc 2017;80:389–90.

[48] Kabasakal Cetin A, Dasgin H, Gülec A, et al. Maternal low quality protein diet alters plasma amino acid concentrations of weaning rats. Nutrients 2015;7:9847–59.

[49] Lee WL, Tsui KH, Wang PH. Is nutrition deficiency a key factor of adverse outcomes for pregnant adolescent? J Chin Med Assoc 2016;79:301–3.

[50] Wang PH, Liu WM, Fuh JL, et al. Symptomatic myoma treated with laparoscopic uterine vessel occlusion and subsequent immediate myomectomy: which is the optimal surgical approach? Fertil Steril 2009;92:762–9.

[51] Wen KC, Sung PL, Chao KC, et al. A prospective short-term evaluation of uterine leiomyomas treated by myomectomy through conventional laparotomy or ultraminilaparotomy. Fertil Steril 2008;90:2361–6.

[52] Li C, Liu Y, Zhang W. Joint and independent associations of gestational weight gain and prepregnancy body mass index with outcomes of pregnancy in Chinese women: a retrospective cohort study. PLoS One 2015;10:e0136850.

[53] Faucher MA, Hastings-Tolsma M, Song JJ, et al. Gestational weight gain and preterm birth in obese women: a systematic review and meta-analysis. BJOG 2016;123:199–206.

[54] Kapadia MZ, Park CK, Beyene J, et al. Can we safely recommend gestational weight gain below the 2009 guidelines in obese women? A systematic review and meta-analysis. Obes Rev 2015;16:189–206.