Postprint of a Comparative Study Evaluating Gestational Weight Gain and Pregnancy Outcomes in Chinese Singleton Pregnant Women Using Chinese Health Industry Standards and American Medical Association Guidelines

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Abstract

Background Appropriate gestational weight gain is crucial for maternal and infant health. Clinically, China has long adopted the Institute of Medicine (IOM) standards to guide gestational weight gain in pregnant women. Since October 2022, China has officially promulgated and implemented the Chinese health industry standard (WS/T 801-2022) to guide gestational weight gain in pregnant women.

Objective To compare the distribution of gestational weight gain and the occurrence of adverse pregnancy outcomes among singleton pregnant women in China when evaluated using the Chinese health industry standard versus the IOM recommended ranges, thereby providing clinical evidence for the domestic application of the Chinese health industry standard.

Methods The data for this study were derived from a prospective cohort study. The study subjects were singleton pregnant women who delivered at Beijing Obstetrics and Gynecology Hospital, Capital Medical University and participated in the Beijing Birth Cohort Study (registration number ChiCTR220058395) between May 2020 and September 2021. Baseline information of the study subjects was collected, and data on gestational complications and pregnancy outcomes were obtained from the clinical medical record system. Based on the recommended gestational weight gain values for singleton pregnant women from both the Chinese health industry standard and the US IOM, the distribution of weight gain among pregnant women under different standards was compared; and pregnant women were divided into five groups: inadequate weight gain (IOM+WS), inadequate weight gain (IOM) + appropriate weight gain (WS),

appropriate weight gain (IOM+WS), appropriate weight gain (IOM) + excessive weight gain (WS), and excessive weight gain (IOM+WS). The risk of adverse pregnancy outcomes [large for gestational age (LGA), small for gestational age (SGA), macrosomia, low birth weight infants, preterm infants] in each weight gain group was analyzed after adjusting for confounding factors.

Results A total of 11,839 singleton pregnant women were included in the study. According to the US IOM standard, the proportions of pregnant women with inadequate weight gain (IOM), appropriate weight gain (IOM), and excessive weight gain (IOM) were 36.7% (4,339/11,839), 38.9% (4,601/11,839), and 24.5% (2,899/11,839), respectively; according to the Chinese health industry standard, the proportions of pregnant women with inadequate weight gain (WS), appropriate weight gain (WS), and excessive weight gain (WS) were 16.2% (1,913/11,839), 45.0% (5,332/11,839), and 38.8% (4,594/11,839), respectively. The proportions of pregnant women in the inadequate weight gain (IOM+WS) group, inadequate weight gain (IOM) + appropriate weight gain (WS) group, appropriate weight gain (IOM+WS) group, appropriate weight gain (IOM) + excessive weight gain (WS) group, and excessive weight gain (IOM+WS) group were 16.2% (1,913/11,839), 20.5% (2,426/11,839), 24.6% (2,907/11,839), 14.3% (1,694/11,839), and 24.5% (2,899/11,839), respectively. Multivariate Logistic regression analysis showed that the risk of overall adverse pregnancy outcomes in the appropriate weight gain (IOM) + excessive weight gain (WS) group was higher than that in the appropriate weight gain (IOM+WS) group [aOR=1.23, 95%CI (1.07, 1.41), P<0.05]. The risk of overall adverse pregnancy outcomes in the inadequate weight gain (IOM) + appropriate weight gain (WS) group showed no difference compared with the appropriate weight gain (IOM+WS) group [aOR=1.02, 95%CI (0.89, 1.16), P<0.05]. The group with excessive weight gain (IOM+WS) in early and mid-pregnancy had a higher risk of LGA, macrosomia, cesarean delivery, and overall adverse pregnancy outcomes than the appropriate weight gain (IOM+WS) group (P<0.05).

Conclusion Adopting the Chinese health industry standard would result in more pregnant women falling within the appropriate weight gain range, with better pregnancy outcomes compared to using the US IOM standard. Therefore, the Chinese health industry standard is more suitable for weight management in Chinese pregnant women, and avoiding excessive weight gain in early and mid-pregnancy is particularly important.

Full Text

Abstract

Background Adequate gestational weight gain (GWG) is critical for maternal and child health. The Institute of Medicine (IOM) standard has long been adopted in clinical practice to guide GWG in China. Since October 2022, China has officially promulgated and adopted the Standard of Recommendation for Weight Gain during Pregnancy Period (WS/T 801-2022) (hereinafter referred

to as SRWGPP) to guide GWG.

Objective To compare the distribution of GWG recommended by the SRWGPP and IOM used for Chinese singleton pregnant women and associated adverse pregnancy outcomes, providing clinical evidence for further application of the SRWGPP.

Methods The data of this study were from a prospective cohort study involving singleton pregnant women who gave birth in Beijing Obstetrics and Gynecology Hospital, Capital Medical University from May 2020 to September 2021 and participated in the Beijing Birth Cohort Study (registration number: ChiCTR220058395). Baseline information was collected from the participants, and the incidence of pregnancy complications and outcomes was obtained from the clinical health record system. We compared the distribution of GWG of the participants based on the criteria by the SRWGPP and the IOM guidelines. Then we divided the participants into five groups: insufficient weight gain (IOM+WS), insufficient weight gain (IOM) + appropriate weight gain (WS), appropriate weight gain (IOM+WS), appropriate weight gain (IOM) + excessive weight gain (WS), and excessive weight gain (IOM+WS). The risk of adverse pregnancy outcomes [large for gestational age (LGA), small for gestational age (SGA), macrosomia, low birth weight, and preterm birth] was analyzed after adjusting for confounding factors.

Results A total of 11,839 singleton pregnant women were included. The proportions of women with insufficient, appropriate, and excessive GWG were 36.7% (4,339/11,839), 38.9% (4,601/11,839), and 24.5% (2,899/11,839), respectively, according to the IOM standard, and were 16.2% (1,913/11,839), 45.0% (5,332/11,839), and 38.8% (4,594/11,839), respectively, according to the SRWGPP. The proportions of pregnant women in groups of IOM+WS, IOM+IW+AW, IOM+AW, IOM+AW+EW and IOM+EW were 16.2% (1,913/11,839), 20.5% (2,426/11,839), 24.6% (2,907/11,839), 14.3% (1,694/11,839) and 24.5% (2,899/11,839), respectively. The results from multivariate logistic regression analysis showed that the risk of overall adverse pregnancy outcomes in IOM+AW+EW group was higher than that in IOM+AW group [aOR=1.23, 95%CI(1.07,1.41), P<0.05] . There was no difference in the risk of overall adverse pregnancy outcomes between IOM+IW+AW group and IOM+AW group [aOR=1.02, 95%CI(0.89,1.16), P<0.05] . The risk of LGA, macrosomia, cesarean section, or the overall adverse pregnancy outcomes was higher in IOM+EW group than that in IOM+AW group either in the first or second trimesters (P<0.05).

Conclusion The adoption of the SRWGPP will allow more pregnant women to meet the appropriate range for GWG, and their pregnancy outcomes will be better than those using the IOM standard. Therefore, the SRWGPP is more applicable to Chinese pregnant women for pregnancy weight management. Especially, it is critical to avoid excessive GWG in the first and second trimesters.

Keywords Obesity, maternal; Pregnancy complications; Gestational weight

gain; Institute of Medicine; WS/T

Introduction

Appropriate gestational weight gain is essential to meet fetal growth requirements, accommodate maternal physiological changes during pregnancy, and prepare for postpartum lactation. Excessive gestational weight gain not only increases the risk of maternal complications such as gestational diabetes mellitus (GDM), hypertensive disorders of pregnancy, cesarean delivery, and postpartum obesity, but also predisposes the fetus to macrosomia, large for gestational age (LGA), and increased risk of obesity in adulthood [**?**]. Conversely, inadequate gestational weight gain can lead to intrauterine growth restriction and increase the risk of small for gestational age (SGA) and low birth weight infants [**?**]. Therefore, maintaining appropriate gestational weight gain is crucial for both immediate and long-term maternal and child health [**?**].

China has long lacked specific standards for gestational weight gain in Chinese pregnant women, with clinical management widely adopting the Institute of Medicine (IOM) recommended ranges [**?**]. The IOM standard has been extensively applied in multiple countries including Australia, Ireland, Canada, and China [**?**]. However, its development was primarily based on data from Caucasian populations in the United States [**?**]. Given the significant differences in genetic characteristics and living environments between Chinese and American populations, substantial questions have been raised regarding the applicability of this standard to Chinese pregnant women [**?**, **?**]. Japan, which has similar population characteristics to China, has proposed gestational weight gain recommendations far lower than those of the IOM [**?**]. Since October 2022, China has officially implemented the national health industry standard (WS/T 801-2022) (hereinafter referred to as the WS standard), "Standard of Recommendation for Weight Gain during Pregnancy Period" [**?**]. By primarily considering the comprehensive impact of gestational weight gain on both SGA and LGA, this standard has established recommended values for gestational weight gain in singleton pregnant women that are significantly lower than the IOM recommendations [**?**].

Whether the Chinese WS standard is more suitable for Chinese pregnant women than the IOM standard remains unclear due to a lack of relevant research. This study utilizes data from the Beijing Birth Cohort Study to compare gestational weight gain status and perinatal outcomes in Chinese singleton pregnant women using the Chinese WS standard versus the American IOM standard, and to explore whether the Chinese WS standard is superior to the American IOM standard for gestational weight management in Chinese pregnant women.

Methods

Study Subjects

This study utilized data from a prospective cohort study. The participants were singleton pregnant women who delivered at Beijing Obstetrics and Gynecology Hospital, Capital Medical University between May 2020 and September 2021 and participated in the Beijing Birth Cohort Study (registration number: ChiCTR220058395).

Inclusion criteria: (1) Age $\geq$ 18 years; (2) Regular prenatal care and delivery at Beijing Obstetrics and Gynecology Hospital, Capital Medical University; (3) Singleton live birth.

Exclusion criteria: (1) Refusal to participate or failure to sign informed consent; (2) Pre-existing diabetes, chronic hypertension, cardiovascular or cerebrovascular disease, liver disease, or kidney disease; (3) Height <140 cm or pre-pregnancy weight >125 kg.

This study was approved by the Ethics Research Committee of Beijing Obstetrics and Gynecology Hospital, Capital Medical University (2018-ky-009-01), and all participants signed informed consent forms.

Research Methods

Cohort follow-up and data collection: During early pregnancy (6-13 weeks), eligible participants were recruited and informed consent was obtained. Trained researchers and physicians collected baseline information, height, and pre-pregnancy weight. Participants were followed up, and weight at admission for delivery was measured. Information on pregnancy complications (including gestational hypertension and GDM) and pregnancy outcomes (including delivery mode, gestational age at delivery, neonatal sex, and weight) was obtained from the clinical medical record system. Maternal weight was measured to the nearest 0.1 kg, and neonatal weight to the nearest 1 g.

Grouping criteria: Pre-pregnancy BMI was calculated based on height and pre-pregnancy weight: BMI (kg/m^2) = pre-pregnancy weight (kg) / height^2 (m^2). Participants were categorized as underweight, normal weight, overweight, and obese according to pre-pregnancy BMI <18.5 kg/m^2, 18.5 kg/m^2 $\leq$ BMI <24 kg/m^2, 24 kg/m^2 $\leq$ BMI <28 kg/m^2, and BMI \$ $28kg/m\hat{}\{2\}$\$ [**?**]. Due to sample size considerations, overweight and obese pregnant women were combined for analysis.

According to the American IOM standard: For pre-pregnancy BMI <18.5 kg/m^2, 18.5 kg/m^2 $\leq$ BMI <25 kg/m^2, 25 kg/m^2 $\leq$ BMI <30 kg/m^2, and BMI \$ $30kg/m\hat{}\{2\}$\$, the recommended total weight gain ranges were 12.5-18 kg, 11.5-16 kg, 7-11.5 kg, and 5-9 kg, respectively. Appropriate early pregnancy weight gain was 0.5-2 kg, with weekly weight gain in the second and third trimesters of 0.44-0.58 kg, 0.35-0.50 kg, 0.23-0.33 kg, and 0.17-0.27 kg as

thresholds [**?**]. Using gestational weeks 0-13, 14-27, and $ $28 as boundaries, appropriate weight gain for early, middle, and late pregnancy was calculated. Pregnant women with gestational weight gain below the lower limit, within the appropriate range, and above the upper limit were classified as insufficient weight gain (IOM), appropriate weight gain (IOM), and excessive weight gain (IOM), respectively.

According to the Chinese WS standard: For pre-pregnancy BMI <18.5 kg/m^2, 18.5 kg/m^2 ≤ BMI <24 kg/m^2, 24 kg/m^2 ≤ BMI <28 kg/m^2, and BMI $ $28kg/m^{2}$$, the recommended total weight gain ranges were 11-16 kg, 8-14 kg, 7-11 kg, and 5-9 kg, respectively. Appropriate early pregnancy weight gain was 0-2 kg, with weekly weight gain in the second and third trimesters of 0.37-0.56 kg, 0.26-0.48 kg, 0.22-0.37 kg, and 0.15-0.30 kg as thresholds [**?**]. Pregnant women with gestational weight gain below the lower limit, within the appropriate range, and above the upper limit in each trimester were classified as insufficient weight gain (WS), appropriate weight gain (WS), and excessive weight gain (WS), respectively.

Since the Chinese WS standard thresholds are significantly lower than the American IOM standard, this study further divided pregnant women into five groups based on the above classifications for pregnancy outcome analysis: insufficient weight gain (IOM+WS) group, insufficient weight gain (IOM) + appropriate weight gain (WS) group, appropriate weight gain (IOM+WS) group, appropriate weight gain (IOM) + excessive weight gain (WS) group, and excessive weight gain (IOM+WS) group.

Outcome measures: The primary outcome of this study was overall adverse pregnancy outcomes, defined as the occurrence of one or more adverse outcomes including LGA, SGA, macrosomia, low birth weight infants, or preterm infants. Neonatal birth weight at or above the 90th percentile and at or below the 10th percentile for gestational age and sex were defined as LGA and SGA, respectively [**?**]. Birth weight $ $4,000 g or <2,500 g was defined as macrosomia or low birth weight, respectively. Delivery before 37 weeks of gestation was defined as preterm birth. Cesarean delivery was also included as a secondary outcome measure.

Definitions of other indicators: GDM was diagnosed according to the "Guidelines for the Diagnosis and Treatment of Hyperglycemia in Pregnancy (2022)" [**?**]. Hypertensive disorders of pregnancy were diagnosed according to the "Guidelines for the Diagnosis and Treatment of Hypertensive Disorders in Pregnancy (2020)" [**?**].

Statistical Methods

Statistical analysis was performed using SAS 9.4. Normally distributed continuous variables were expressed as ($\bar{x}\pm s$) and compared using one-way ANOVA. Categorical variables were expressed as percentages and compared using ^{2} tests. Multivariate logistic regression models were used to examine the odds ratios

(OR) and 95% confidence intervals (CI) for adverse pregnancy outcomes in different weight gain groups, with the appropriate weight gain (IOM+WS) group as the reference. Confounding factors adjusted for were selected based on previous literature and included age, parity, height, pre-pregnancy BMI, GDM, and hypertensive disorders of pregnancy [**?**]. P<0.05 was considered statistically significant.

Results

Basic Characteristics of Pregnant Women

A total of 16,779 women were initially screened. After excluding 2,998 with incomplete information, 147 with miscarriage, stillbirth, or fetal death before 28 weeks, 315 with pre-pregnancy diabetes, chronic hypertension, cardiovascular or cerebrovascular disease, liver or kidney disease, and 1 with height <140 cm, 11,839 singleton pregnant women were included in the study.

Among the 11,839 participants, 74.8% (8,858/11,839) were nulliparous, with a mean age of $(32.5\$\pm3.9)years, meanheightof(162.85\pm5.01)cm, meanpre-pregnancyweightof(57.39\pm8.58)kg, andmeanpre-pregnancyBMIof(21.62\pm2.98)kg/m\hat{}\{2\}.Theproportionsc$g. Macrosomia occurred in 6.3% (744/11,839), low birth weight in 3.4% (400/11,839), LGA in 15.8% (1,873/11,839), and SGA in 5.0% (595/11,839). The prevalence of GDM was 16.6% (1,965/11,839), gestational hypertension 4.2% (501/11,839), and preeclampsia 4.5% (533/11,839).

Distribution of Gestational Weight Gain According to Different Standards

According to the American IOM standard, the proportions of pregnant women with insufficient, appropriate, and excessive weight gain were 36.7% (4,339/11,839), 38.9% (4,601/11,839), and 24.5% (2,899/11,839), respectively. According to the Chinese WS standard, the proportions were 16.2% (1,913/11,839), 45.0% (5,332/11,839), and 38.8% (4,594/11,839), respectively.

Significant differences were observed in the distribution of gestational weight gain between the American IOM standard and Chinese WS standard for all pregnant women, underweight women, normal weight women, and overweight/obese women (P<0.001) .

Comparison of Basic Information Among Weight Gain Groups

The proportions of pregnant women in the insufficient weight gain (IOM+WS) group, insufficient weight gain (IOM) + appropriate weight gain (WS) group, appropriate weight gain (IOM+WS) group, appropriate weight gain (IOM) + excessive weight gain (WS) group, and excessive weight gain (IOM+WS) group were 16.2% (1,913/11,839), 20.5% (2,426/11,839), 24.6% (2,907/11,839), 14.3% (1,694/11,839), and 24.5% (2,899/11,839), respectively. Significant differences were observed among the groups in age, parity, height, pre-pregnancy BMI,

gestational weight gain, delivery weight, cesarean delivery rate, gestational age at delivery, and neonatal weight (P<0.05) .

Relationship Between Gestational Weight Gain and Adverse Pregnancy Outcomes

The incidence of adverse pregnancy outcomes including LGA, SGA, macrosomia, low birth weight, preterm birth, and overall adverse pregnancy outcomes in each weight gain group is shown in and .

Multivariate Logistic Regression Analysis of Gestational Weight Gain and Adverse Pregnancy Outcomes

After adjusting for age (continuous variable), parity (nulliparous=0, multiparous=1), height (continuous variable), pre-pregnancy BMI (continuous variable), GDM (no=0, yes=1), and hypertensive disorders of pregnancy (no=0, yes=1), multivariate logistic regression analysis showed that in all pregnant women and normal weight women, the appropriate weight gain (IOM) + excessive weight gain (WS) group and excessive weight gain (IOM+WS) group had higher risks of LGA, macrosomia, cesarean delivery, and overall adverse pregnancy outcomes compared to the appropriate weight gain (IOM+WS) group (P<0.05). The insufficient weight gain (IOM+WS) group had higher risks of SGA, low birth weight infants, preterm infants, and overall adverse pregnancy outcomes compared to the appropriate weight gain (IOM+WS) group (P<0.05). In all pregnant women, the insufficient weight gain (IOM) + appropriate weight gain (WS) group had higher risks of low birth weight infants and preterm infants compared to the appropriate weight gain (IOM+WS) group (P<0.05). In normal weight women, the insufficient weight gain (IOM) + appropriate weight gain (WS) group had higher risk of low birth weight infants compared to the appropriate weight gain (IOM+WS) group (P<0.05) .

Multivariate Logistic Regression Analysis of Weight Gain by Trimester and Adverse Pregnancy Outcomes

This study further analyzed the relationship between weight gain in early, middle, and late pregnancy and adverse pregnancy outcomes. The results showed that excessive weight gain (IOM+WS) in early and middle pregnancy was associated with higher risks of LGA, macrosomia, cesarean delivery, and overall adverse pregnancy outcomes compared to appropriate weight gain (IOM+WS), while excessive weight gain (IOM+WS) in middle pregnancy was associated with lower risk of SGA (P<0.05). Insufficient weight gain (IOM+WS) and insufficient weight gain (IOM) + appropriate weight gain (WS) in middle pregnancy were associated with higher risks of low birth weight infants and preterm infants, and lower risk of LGA compared to appropriate weight gain (IOM+WS) (P<0.05). Insufficient weight gain (IOM+WS) in middle pregnancy was associated with higher risk of preterm infants compared to appropriate weight

gain (IOM+WS). In late pregnancy, appropriate weight gain (IOM) + excessive weight gain (WS) was associated with lower risks of LGA, macrosomia, and overall adverse pregnancy outcomes compared to appropriate weight gain (IOM+WS), while insufficient weight gain (IOM+WS) in late pregnancy was associated with higher risks of low birth weight infants and preterm infants compared to appropriate weight gain (IOM+WS) .

Discussion

Both excessive and insufficient gestational weight gain seriously affect maternal and child health, making gestational weight management a critical component of prenatal care. However, China has long lacked relevant standards for gestational weight management during pregnancy. Whether the newly implemented Chinese WS standard in October 2022, which specifies lower recommended values for gestational weight gain in singleton pregnant women, is more suitable for Chinese pregnant women than the previously used American IOM standard remains unsupported by research evidence. This study utilized a prospective cohort database to analyze the status of gestational weight gain in Chinese singleton pregnant women as defined by the Chinese WS standard versus the American IOM standard, and compared the incidence of adverse pregnancy outcomes among different weight gain groups. The results showed that using the Chinese WS standard, fewer pregnant women were classified as having insufficient weight gain, while more were classified as having appropriate or excessive weight gain. Compared to the appropriate weight gain group, exceeding the upper limit of the Chinese WS standard or falling below its lower limit increased the risk of overall adverse pregnancy outcomes, regardless of whether the weight gain met IOM standards. Conversely, when weight gain was below the IOM standard lower limit but within the appropriate range of the Chinese WS standard, no increased risk of overall adverse pregnancy outcomes was observed. These findings suggest that the Chinese WS standard is more applicable to Chinese pregnant women. However, the impact of weight gain during different trimesters on pregnancy outcomes varies, with excessive weight gain in early and middle pregnancy being a risk factor for adverse pregnancy outcomes.

Distribution of Weight Gain Using Chinese WS Standard Versus American IOM Standard

This study first analyzed the distribution of gestational weight gain in pregnant women according to the Chinese WS standard and American IOM standard. The results showed that using the Chinese WS standard, more pregnant women were classified as having appropriate gestational weight gain. Compared to the 36.7% of pregnant women classified as having insufficient weight gain according to the IOM standard, only 16.2% were classified as insufficient according to the Chinese WS standard, while approximately 45% were classified as having appropriate weight gain. This will significantly alleviate pregnant women's anxiety about fetal malnutrition due to traditional beliefs, thereby improving the

current situation of excessive energy intake among Chinese pregnant women [**?**]. According to dietary survey results from 8 Chinese cities, Chinese pregnant women generally have excessive energy intake, primarily from excessive fat intake, highlighting the focus of current nutritional management during pregnancy [**?**]. Particularly, the obesity rate among Chinese women of reproductive age has risen rapidly in recent years [**?**], and the status of excessive gestational weight gain is concerning. National multicenter survey data from 2011 and the "China Nutrition and Health Surveillance (2010-2013)" covering 30 provinces showed that even according to the American IOM standard, 36.6%-38.2% of pregnant women had excessive gestational weight gain [**?**]. Both this study and previous research have shown that the incidence of macrosomia in China is increasing year by year [**?**], highlighting the urgent need for management of pregnant women with excessive weight gain.

Comparison of Adverse Pregnancy Outcomes Using Chinese WS Standard Versus American IOM Standard

This study further explored whether the lower gestational weight gain standards affect the incidence of adverse pregnancy outcomes. The selection of outcome measures referenced both the Chinese WS standard and American IOM standard. The Chinese WS standard primarily incorporated LGA and SGA as indicators, while also considering their impact on pregnancy complications and outcomes (SGA, LGA, low birth weight infants, macrosomia, cesarean delivery, etc.). The IOM standard development utilized outcome measures including cesarean delivery, postpartum weight retention, preterm birth, SGA, LGA, and childhood obesity. This study used five indicators—LGA, SGA, macrosomia, low birth weight infants, and preterm birth—to comprehensively reflect overall adverse pregnancy outcomes, all of which have been reported to be closely related to gestational weight gain in previous studies [**?**]. The results showed that when pregnant women's weight gain exceeded the upper limit of the Chinese WS standard, even if still within the IOM recommended range, the risk of adverse pregnancy outcomes significantly increased. On the other hand, when weight gain was below the IOM standard lower limit but within the appropriate range of the Chinese WS standard, no increased risk of overall adverse pregnancy outcomes was observed. These findings suggest that compared to the IOM guidelines, adopting the gestational weight gain recommendations for singleton pregnant women specified in the Chinese WS standard is more likely to result in favorable pregnancy outcomes. This is consistent with previous studies reporting that recommended gestational weight gain values for Chinese singleton pregnant women should be lower than IOM recommendations [**?**, **?**]. Since this study could not distinguish the indications for cesarean delivery, cesarean delivery was not included in the overall adverse pregnancy outcome indicators but was analyzed as a secondary outcome. The relationship between cesarean delivery and gestational weight gain was similar to that of overall adverse pregnancy outcomes. Additionally, due to limited sample sizes of underweight, overweight, and obese pregnant women, analysis of these subgroups only revealed

that weight gain insufficiency or excess meeting both IOM and WS standards increased the risk of adverse pregnancy outcomes. Whether outcomes are affected in populations meeting only IOM standards or only WS standards remains uncertain.

Since previous studies have reported that weight gain during different pregnancy stages has inconsistent effects on perinatal outcomes [**?**], this study further analyzed the impact of weight gain in early, middle, and late pregnancy on perinatal outcomes. The results indicated that excessive weight gain in early and middle pregnancy increased the risk of macrosomia, LGA, and overall adverse pregnancy outcomes, while the effect of insufficient weight gain on health outcomes was inconsistent across subgroups. No impact of insufficient early pregnancy weight gain on pregnancy outcomes was observed. These findings provide scientific evidence for early clinical intervention to prevent excessive weight gain.

Strengths and Limitations of This Study

This study provides evidence supporting the application of the Chinese WS standard for gestational weight gain management in Chinese singleton pregnant women through analysis of a prospective cohort database. However, this study has several limitations. First, it is a single-center study that only included pregnant women from northern China; further research is needed for pregnant women in other geographical regions of China. Second, the sample sizes for underweight, overweight, and obese pregnant women were limited, preventing definitive conclusions for these subgroups. Additionally, this study did not evaluate long-term outcomes such as maternal postpartum status and childhood obesity in offspring, which require further long-term follow-up studies. Addressing these issues will require validation through large-scale, multicenter national studies.

In conclusion, compared to the American IOM guidelines, adopting the gestational weight gain recommendations for singleton pregnant women specified in the Chinese WS standard allows more Chinese pregnant women to be classified as having appropriate weight gain and is associated with better pregnancy outcomes. Therefore, the Chinese WS standard is more applicable to Chinese pregnant women than the American IOM guidelines. However, this conclusion requires further validation through large-scale, multicenter national cohort studies.

Author Contributions: Zhang Li and Zheng Wei were responsible for study design and implementation, manuscript writing and revision; Wang Jia, Yuan Xianxian, Han Weiling, and Huang Junhua were responsible for data collation; Zheng Wei and Tian Zhihong were responsible for data analysis; Li Guanghui was responsible for study design guidance and manuscript revision.

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Note: Figure translations are in progress. See original paper for figures.