The impact of excluding adverse neonatal outcomes on the creation of gestational weight gain charts among women from low- and middle-income countries with normal and overweight BMI

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The impact of excluding adverse neonatal outcomes on the creation of gestational weight gain charts among women from low- and middle-income countries with normal and overweight BMI

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Abstract

Background: Existing gestational weight gain (GWG) charts vary considerably in their choice of exclusion/inclusion criteria, and it is unclear to what extent these criteria create differences in the charts' percentile values. We aimed to establish the impact of including/excluding pregnancies with adverse neonatal outcomes when constructing GWG charts.

Methods: This is an individual participant data analysis from 31 studies from low- and middle-income countries. We created a dataset that included all participants and a dataset restricted to those with no adverse neonatal outcomes: preterm < 37 weeks, small or large for gestational age – SGA or LGA, low birth weight < 2,500 g, or macrosomia > 4,000 g. Quantile regression models were used to create GWG curves from 9 to 40 weeks, stratified by pre-pregnancy BMI, in each dataset.

Results: The dataset without the exclusion criteria applied included 14,685 individuals with normal weight and 4,831 with overweight. After removing adverse neonatal outcomes, 10,479 individuals with normal and 3,466 individuals with overweight remained. GWG distributions at 13, 27, and 40 weeks were virtually identical between the datasets with and without the exclusion criteria, except at 40 weeks for normal weight and 27 weeks for overweight. For the 10^{th} and 90^{th} percentiles, the differences between the estimated GWG were larger for overweight (approximately 1.5 kg) compared to normal weight (< 1 kg). Removal of adverse neonatal outcomes had minimal impact on GWG trajectories of normal weight. For overweight, the percentiles estimated in the dataset without the criteria were slightly higher than those in the dataset with the criteria applied. Nevertheless, differences were < 1 kg and virtually nonexistent at the end of pregnancy.

Conclusions: Removing pregnancies with adverse neonatal outcomes had little or no influence on the GWG trajectories of individuals with normal and overweight.

Abbreviations

BMI: Body mass index

GA: Gestational age

GWG: Gestational weight gain

IPD: Individual participant data

Ki: Knowledge integration

LBW: Low birth weight

LGA: Large for gestational age

LMICs: low- and middle-income countries

SGA: Small for gestational age

WHO: World Health Organization

Keywords: gestational weight gain; reference; standards; adverse neonatal outcomes

Introduction

Gestational weight gain (GWG) is an important indicator to be monitored during pregnancy because deviations in this indicator are associated with adverse outcomes for both mothers and their infants (1-3). Several GWG curves have been created in the last ten years using national or local data to facilitate the monitoring of GWG during prenatal care (4-11).

Although most of the GWG curves have tried to adopt a prescriptive approach – i.e., charts were constructed using data from a selective, low-risk population to describe how weight gain *ought* to be (12), there is an inconsistency among the criteria adopted in defining the underlying sample to construct the curves. One of these criteria is the removal of individuals who gave birth to children with adverse neonatal outcomes, such as preterm birth, small- (SGA) or large-for-gestational-age (LGA) births, low birth weight (LBW), or macrosomia. Several studies removed individuals who gave birth to preterm infants (4, 5, 7, 9, 10), and some of them also mentioned the removal of individuals based on birth weight (7-10). However, in several studies, including in the INTERGROWTH-21st standards, there is no mention of individuals with those characteristics being removed (6, 11, 13).

The decision to include or exclude pregnancies with adverse neonatal outcomes from GWG curves is an important design consideration for ongoing initiatives to create charts, such as the World Health Organization's (WHO) new initiative to develop global standards for GWG (14). Excluding individuals who gave birth to neonates with adverse outcomes has major implications for sample size. If excluding those individuals is necessary, investigators will have to recruit larger samples in early pregnancy to account for those subsequent exclusions. This consideration is especially relevant for researchers from low- and middle-income countries (LMICs), where the prevalence of many adverse neonatal outcomes is higher than in other regions. However, if the exclusion of pregnancies with adverse neonatal outcomes has little practical impact on the chart percentiles, this exclusion may not be necessary. The goal of this study was to identify the impact of removing participants with adverse neonatal outcomes (preterm birth, SGA, LGA, LBW, and macrosomia) when constructing GWG curves, using a pooled dataset from studies conducted in LMICs.

Methods

Study design and selection of study population

This analysis used data from the GWG Pooling Project, a cohort of individual participant data (IPD) from multiple studies that addressed various knowledge gaps of the determinants and consequences of inadequate and excessive GWG in LMICs. The details of the GWG Pooling Project have been described elsewhere (15).

In February and March 2019, the GWG Pooling Project team conducted a systematic search using PubMed, Embase, and Web of Science. The search aimed to identify randomized controlled trials and observational cohort studies that collected multiple weight measurements among pregnant individuals (pregnant at enrollment or enrolled before pregnancy and followed up in pregnancy) in low-income, lower-middle-income, or upper-middle-income economies, defined by the World Bank country classification for the 2019 fiscal year. No language restrictions were imposed, but a publication date restriction of 2000 and later was defined, to capture relatively recent studies for generalizability. Studies were excluded if they did not collect two or more measures of gestational weight or only collected self-reported gestational weight. Studies conducted exclusively among women with pre-existing health conditions, such as anemia, human immunodeficiency virus infection, or diabetes were also excluded.

Two team members independently screened the titles and abstracts of the identified studies based on the eligibility criteria, with any discrepancies resolved by discussion. They also reviewed the full texts of the remaining studies to confirm final eligibility, with any discrepancies resolved by discussion. For studies that remained after the full-text screening, individual study investigators were invited to participate in a survey designed to confirm study eligibility and to indicate their willingness to contribute individual-level data. For study teams willing to participate, the Knowledge Integration

(Ki) team at the Bill & Melinda Gates Foundation worked with the principal investigators of the studies to pursue data contributor agreements with the respective institutions. As IPD became available, we worked with the Ki team to examine data completeness, map relevant variables, and harmonize the data across studies. Contributed data were harmonized based on a pre-specified variable list and variable definition. We systematically assessed whether the variables included in the analysis were defined consistently across all studies. Among the 337 investigators contacted, approximately 50% responded to the survey, of whom 145 led studies that were eligible for the pooled analysis and were invited to contribute data, out of which 56 studies made IPD available to the project (**Supplementary Figure 1**).

For the present study, we included adult pregnant individuals (19 - 45 years old), with singleton pregnancies, without a record of abortion, stillbirth, neonatal, or maternal death in the current pregnancy. We excluded records with implausible gestational age estimates (outside the 1-301 days interval), implausible GWG measurements, and missing initial weights.

We identified and removed biologically implausible values (outliers) and assessed the heterogeneity of GWG data across the included studies (**Supplementary Methods**). We removed all measurements flagged as implausible using the selected cross-sectional and longitudinal methods and studies with GWG measurements considered heterogeneous. We also removed GWG measurements obtained < 9 and > 40 weeks due to sample size reasons and because no weight gain related to pregnancy is expected before 9 weeks (16). The dataset retained only a small sample size for the underweight (n = 3,091 individuals; 7,415 repeated measurements; 12% of the sample) and obesity (n = 2,106 individuals; 3,630 measurements; 8.2% of the sample) BMI categories after implementing those procedures, which made it uninformative to consider these BMI categories in the analyses.

To create the dataset without applying the neonatal exclusion criteria, we selected only individuals classified as normal or overweight according to pre-pregnancy BMI (17). From this dataset, we also removed those with missing data in the variables necessary to construct the neonatal outcomes, i.e., birth weight, sex of the newborn, and gestational age at birth.

Creation of the dataset after applying the neonatal exclusion criteria

This dataset was created by excluding all individuals who gave birth to an infant classified as preterm (gestational age at birth < 37 completed weeks) (18), SGA (birth weight < 10^{th} percentile of the INTERGROWTH-21^{st} newborn size standards)(19), LGA (birth weight > 90^{th} percentile of the INTERGROWTH-21^{st} newborn size standards) (19), with LBW (birth weight < 2,500 g), or macrosomia (birth weight > 4,000 g).

Main variables

GWG was calculated as the difference between the weight in each prenatal care or study visit and an initial weight. This initial weight was chosen using the following hierarchy of available data: 1) measured pre-pregnancy weight, 2) measured first-trimester weight up to 8 weeks of pregnancy, and 3) self-reported pre-pregnancy weight or a pre-pregnancy weight abstracted from medical records.

Pre-pregnancy BMI was calculated using the initial weight in kilograms, and the first registered height, in meters squared. BMI (kg/m^2) was then classified according to the World Health Organization (WHO) cut-offs as underweight (< 18.5 kg/m^2), normal weight (≥ 18.5 and < 25.0 kg/m^2), overweight (≥ 25.0 and < 30.0 kg/m^2) and obesity (≥ 30.0 kg/m^2) (17).

Gestational age (GA) was ascertained through various methods across the contributing studies. When multiple methods for ascertaining GA were used in a single study, preferences were given in the following order (from the most prioritized to the least prioritized): crown-rump length, fetal biometry (biparietal diameter and femur length), best obstetric estimate, GA as reported by the ultrasound machine, last menstrual period, new Ballard score, GA as provided in the raw data, and the estimated date of delivery.

Ethics

This is a secondary analysis of existing data. All studies included in this analysis were approved by their respective ethics committees.

Statistical analyses

Characteristics of the study population were described by calculating the 25th, 50th (median), and 75th percentiles for continuous variables and counts with percentages for categorical ones. The analyses were stratified by normal weight and overweight pre-pregnancy BMI categories only.

To account for the non-linear relationship between GWG and GA, we identified the best fitting powers for the GWG curves using second-degree fractional polynomials (20), which were further modeled in quantile regressions with robust errors. Quantile regressions with robust errors were used to create GWG curves from 9 to 40 weeks for the 10th, 25th, 50th, 75th, and 90th percentiles. The predicted GWG values with accompanying 95% confidence intervals for the 25th, 50^{th,} and 75th percentiles for pre-

pregnancy normal and overweight at 13, 27, and 40 weeks were compared. Differences between the percentiles were considered clinically meaningful if they were > 1 kg. Density plots were created to compare the distributions of GWG in each dataset at 13, 27, and 40 weeks for normal and overweight pregnant individuals. The predicted 10th and 90th percentiles from the quantile regressions were added to the graphs. The analyses were performed in R, version 4.2.0, and Stata, version 15.

Results

The initial pooled dataset comprised 56 studies and 109,567 individuals with 689,196 measurements. Initial data cleaning and application of eligibility criteria reduced the dataset to 28,176 individuals and 66,151 measurements (**Figure 1**).

The cross-sectional methods applied identified 1,359 individuals and 4,970 weight measurements and 17 pre-pregnancy BMI measurements as outliers (data not shown). Subsequently, the identification of longitudinal outliers flagged 23 individuals and 161 measurements as implausible that were removed from the dataset (**Supplementary Figure 2**).

Several studies in both BMI categories had heterogenous GWG distribution (**Supplementary Figure 3**). Therefore, 669 individuals and 5,584 GWG measurements were removed from studies or visits conducted in intervals in which the study was considered heterogeneous. GWG measurements taken outside the 9-40 weeks range were removed, resulting in a dataset with 25,532 individuals and 53,631 measurements. Finally, removing individuals with pre-pregnancy underweight and obesity and with missing data on birth variables resulted in the dataset without the neonatal exclusion criteria applied, with 14,685 individuals with normal weight and 4,831 with overweight, with 32,130 and 8,825 weight gain measurements, respectively (**Figure 1**). Of these, 10,479 individuals and 22,118 GWG measurements for normal weight and 3,466 individuals and 6,232 GWG measurements for overweight remained after application of the neonatal exclusion criteria.

The dataset for normal weight comprised data from 16 countries; for overweight, 13 countries were included. Among normal weight participants, the median (IQR) maternal age was 27.0 years (24.0 – 30.0), while for overweight, the median (IQR) age was 30.0 (26.0 – 33.0) years. The prevalence of LGA was 9.8% for normal weight and 14.4% for overweight. The prevalence of preterm birth (8.3 vs. 6.7%) and macrosomia (4.3 vs. 3.1%) was also higher among overweight individuals (**Table 1**). We did not observe any differences in the distribution of key variables (BMI, GWG, maternal age) in the final cohort (**Table 1**) and the data before removing missing data on birth variables (**Supplementary Table 1**). GWG distribution at the end of each trimester (13, 27, and 40 weeks) was virtually identical for both BMI categories, except at 40 weeks for normal and 27 weeks for overweight. For normal weight, there was a shift to the right in the GWG distribution at 40 weeks. For overweight, at 27 weeks, a small shift to the left was observed. When we compared the 10^{th} and 90^{th} percentiles, the differences between the curves created in the dataset with and without the exclusion criteria applied were larger for overweight (approx. 1.5 kg) compared to normal weight individuals (< 1 kg) (**Figures 2 and 3**).

The population-level GWG percentiles of normal-weight individuals were very similar when charts with and without removing the adverse neonatal outcomes were compared. The GWG values at each of the estimated percentiles tended to be higher when those individuals were removed, but the differences were always < 1 kg and virtually nonexistent at the end of pregnancy (**Figure 4A**). For overweight, the GWG values at each of the estimated percentiles tended to be lower when those individuals were removed. The differences between the curves for overweight were also larger when compared to normal weight, especially for the 75th and 90th percentiles. However, at 40 weeks, all differences were < 1 kg (**Figure 4B**).

In general, the GWG values at each of the estimated percentiles of the curves obtained in the dataset without neonatal adverse outcomes were modestly lower than those estimated in the dataset with those outcomes, but differences were all < 1 kg for both BMI categories when the most central percentiles of the distribution (25th, 50th, and 75th) were examined, and confidence intervals were overlapping (**Table 2**). For normal weight women, the predicted GWG 75th percentile at 40 weeks was 9.6 kg in the curve modeled in the dataset without the application of the neonatal exclusion criteria, and 10.1 kg in the curve modeled after removal of those outcomes, representing the largest difference of 0.5 kg. For overweight, the largest difference (0.8 kg) was also observed for the GWG at the 75th percentile at 27 weeks: 8.0 kg in the curves created in the dataset without the criteria applied *v.* 7.2 kg in those created in the dataset after application of the criteria.

Discussion

In this analysis of IPD from multiple LMIC cohorts, the exclusion of individuals who gave birth to neonates who were preterm, classified as SGA or LGA, or with LBW or macrosomia had little or no influence on GWG trajectories and the estimated GWG percentiles throughout pregnancy of mothers with pre-pregnancy normal or overweight. For normal weight, GWG trajectories and the predicted values of GWG at selected percentiles and gestational ages were virtually identical in the datasets with and without the exclusion criteria applied. For overweight, the estimated percentiles for the dataset without excluding the neonatal outcomes were slightly higher than those estimated in the data after removing those, but the differences were always < 1 kg and virtually nonexistent at the end of pregnancy.

There are two possible explanations for the relatively small impact of removing individuals with adverse neonatal outcomes on GWG trajectories. First, individuals with adverse neonatal outcomes constituted only a small fraction of the cohort (< 15%); exclusion of this relatively small number of records may not have been sufficient to influence the GWG trajectories. The exclusion of adverse outcomes with higher prevalence may have a greater influence on GWG trajectories. However, the prevalence of the adverse neonatal outcomes observed in this dataset is similar to those reported in other studies using data from LMICs (21-23), supporting the generalizability of our findings.

A second possible explanation is that the magnitude of the association between GWG and the selected adverse outcomes is modest. Although insufficient and excessive GWG are consistently reported to be associated with those outcomes, the results of meta-analyses show odds ratios between 1.1 – 2.5 (1-3). Farias et al. (24) also showed that the ability of GWG classified according to several curves to predict SGA and LGA in a sample of Brazilian women had low sensitivity and high specificity for both outcomes. The modest magnitude of association and the low ability of GWG to predict those outcomes could help explain the small or no effect that the removal of individuals with adverse outcomes had on the GWG curves.

To the best of our knowledge, this is the first study to analyze the role of excluding adverse neonatal outcomes on GWG charts. The comparison of the values of GWG observed for this set of normal-weight individuals from LMICs with the standards proposed by the INTERGROWTH-21st, created based on data of a highly-selected sample (6) showed that the differences between the predicted GWG at 40 weeks for the

25th, 50th, and 75th were mostly < 1 kg. For example, the 50th percentile of INTERGROWTH-21st standards corresponds to a weight gain of 13.7 kg, while in the dataset of the LMICs data without excluding the adverse neonatal outcomes, the predicted GWG is 12.9 kg.

The practical difference between references and standards has been previously evaluated by Hutcheon and Liauw (25) in the context of fetal growth. These authors observed that the distribution of estimated fetal weight obtained from a reference versus standard population (which included 30% of the referent cohort) from Canada was similar, suggesting that exclusion criteria played no role on the fetal growth charts created from those datasets. This small difference aligns with the results of the current study for GWG.

In many situations, excluding individuals with selected characteristics from GWG charts is the standard procedure adopted without further reflection on the real impact of those factors in the curves. This removal poses a critical constraint on the available sample size for constructing those curves and should be carefully evaluated. In addition, it is important to mention that other relevant factors that should be considered in creating GWG standards, such as excess postpartum weight retention, child obesity, gestational diabetes, and hypertensive disorders of pregnancy, were not evaluated in the current study. Therefore, future studies aiming to develop GWG standards should consider the true influence of removing individuals with those and other characteristics related to GWG in constructing the curves.

The strengths of this study include the use of a large dataset from multiple settings and the application of rigorous procedures to flag and remove implausible values and assess the data's heterogeneity and construct the curves. Limitations include the insufficient data for individuals with underweight and obesity, and the lack of a measured pre-

pregnancy weight. Many studies rely on a first-trimester measurement as a proxy of the weight at conception, which may not be accurate due to expected weight changes in this period. Thus, we decided to create a priority “first weight” variable considering a hierarchy based on agreement analyses performed in the same dataset (data not shown).

The low number of individuals with underweight and obesity is of particular concern, especially the lack of data for underweight individuals in LMICs. Since SGA and LBW are more prevalent among individuals with underweight, it is possible that the exclusion of these pregnancies could have a larger impact on weight gain distributions than among individuals with normal weight. Repeating our analyses in cohorts where undernutrition is more common and the prevalence of averse neonatal outcomes associated with GWG is higher, such as South Asia and Sub-Saharan Africa, would be valuable.

The exclusion of individuals who gave birth to neonates classified as preterm or with SGA, LGA, LBW, or macrosomia had little or no influence on the GWG percentiles of individuals with normal- and overweight. Thus, excluding those individuals from GWG curves may have little practical impact. However, an essential step is to repeat these analyses in cohorts with higher prevalence of underweight and obesity. Combining these findings with results from the present study will allow more definitive conclusions on the need to exclude pregnancies complicated by adverse neonatal outcomes from GWG curves. In addition, future studies considering GWG determinants and other GWG-related outcomes, such as excess postpartum weight retention and child obesity, are needed to clarify the appropriate criteria to be adopted to construct GWG standards.

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TRBC, GK, and JAH planned the data analyses. TRBC analyzed the data and wrote the manuscript with input from DQ, JAH, MW, WWF, and GK. WWF is the coordinator of the GWG pooling project. WWF and GK contributed equally as senior authors. TRBC, JAH, and GK had primary responsibility for the final content. All authors read and approved the final manuscript.

Data Availability

The data that support the findings of this study are available from the Knowledge integration (Ki) initiative (Bill and Melinda Gates Foundation), but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available upon reasonable request and with signature of data access agreements with the Ki.

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Author Disclosures

The authors declare that they have no conflicts to disclose.

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Tables

Table 1. Maternal and neonatal characteristics of the cohort before applying the neonatal exclusion criteria according to pre/early-pregnancy body mass index (BMI) category.

Available variables	Normal weight (BMI ≥ 18.5 and < 25.0 kg/m^2, 14,685 individuals and 32,130 measurements)	Overweight (BMI ≥ 25.0 and < 30.0 kg/m^2, 4,831 individuals and 8,825 measurements)
Continuous	**Median (IQR)**	
Maternal age	27.0 (24.0 – 30.0)	30.0 (26.0 – 33.0)
Maternal pre-/early-pregnancy BMI	21.3 (19.9 – 22.9)	27.1 (25.9 – 28.3)
Gestational weight gain (kg)		
First trimester	0.7 (-0.6 – 2.3)	0.2 (-1.1 – 2.0)
Second trimester	2.5 (0.7 – 4.6)	2.1 (-0.2 – 5.2)
Third trimester	8.1 (4.9 – 12.0)	9.0 (6.0 – 12.5)
Birth weight (g)	3,180 (2,880 – 3,500)	3,250 (2,960 – 3,510)
Gestational age at birth (weeks)	39.4 (38.4 – 40.3)	39.1 (38.1 – 40.0)

Categorical	**Number of individuals (%)**	
Country		
Argentina	658 (4.5)	224 (4.6)
Bangladesh	484 (3.3)	47 (1.0)
Benin	133 (0.9)	29 (0.6)
Brazil	776 (5.3)	350 (7.2)

Burkina Faso	165 (1.1)	4 (0.08)
China	5,788 (39.4)	520 (10.8)
Ghana	154 (1.0)	105 (2.2)
Guatemala	167 (1.1)	110 (2.3)
India	230 (1.6)	48 (1.0)
Islamic Republic of Iran	3,615 (24.6)	3,162 (65.4)
Mexico	311 (2.1)	184 (3.8)
Nepal	1,731 (11.8)	-
Nigeria	34 (0.2)	-
Pakistan	51 (0.3)	9 (0.2)
Papua New Guinea	8 (0.05)	-
The Gambia	380 (2.6)	39 (0.8)
Neonatal outcomes		
Small for gestational age	2,043 (13.9)	386 (8.0)
Large for gestational age	1,444 (9.8)	698 (14.4)
Preterm birth	986 (6.7)	400 (8.3)
Low birth weight	1,043 (7.1)	264 (5.5)
Macrosomia	458 (3.1)	207 (4.3)

Notes: BMI: body mass index; IQR: interquartile range.

Table 2. Smoothed gestational weight gain values and 95% confidence intervals (in kg) for the selected percentiles at the end of each pregnancy trimester.

Percentiles	Normal weight (BMI ≥ 18.5 and < 25.0 kg/m²)			Overweight (BMI ≥ 25.0 and < 30.0 kg/m²)		
	13 weeks (1st trimester)	27 weeks (2nd trimester)	40 weeks (3rd trimester)	13 weeks (1st trimester)	27 weeks (2nd trimester)	40 weeks (3rd trimester)
25th percentile						
Dataset without the exclusion criteria applied	-0.3 (-0.4 – -0.3)	2.7 (2.7 – 2.8)	9.6 (9.4 – 9.8)	-1.3 (-1.6 – -1.1)	2.2 (2.0 – 2.5)	8.5 (8.2 – 8.8)
Dataset with the exclusion criteria applied	-0.3 (-0.4 – -0.3)	3.1 (3.0 – 3.2)	10.1 (9.9 – 10.3)	-1.8 (-2.0 – -1.5)	2.2 (2.0 – 3.3)	8.3 (8.1 – 8.6)
50th percentile						

Dataset without the exclusion criteria applied	1.1 (1.0 – 1.1)	4.8 (4.7 – 4.9)	12.9 (12.7 – 13.0)	0.5 (0.3 – 0.6)	5.1 (4.9 – 5.3)	11.1 (10.9 – 11.3)
Dataset with the exclusion criteria applied	1.1 (1.0 – 1.1)	5.2 (5.1 – 5.3)	13.1 (12.9 – 13.2)	0.4 (0.3 – 0.6)	4.7 (4.6 – 4.8)	11.3 (11.1 – 11.5)
75^{th} percentile						
Dataset without the exclusion criteria applied	2.7 (2.6 – 2.8)	7.1 (7.0 – 7.2)	16.2 (16.0 – 16.4)	2.2 (2.0 – 2.4)	8.0 (7.7 – 8.2)	14.2 (13.8 – 14.5)
Dataset with the exclusion criteria applied	2.7 (2.6 – 2.8)	7.5 (7.4 – 7.6)	16.3 (16.1 – 16.5)	2.4 (2.2 – 2.5)	7.2 (7.1 – 7.3)	14.7 (14.1 – 15.0)

Notes: BMI: body mass index.

Figure legends

Figure 1: Flowchart for the construction of the database.

Notes: **Initial weight refers to a pre-pregnancy weight measured, self-reported or abstracted from medical records or a weight measured at the beginning of pregnancy (up to 8 weeks). Body mass index (BMI) was calculated based on a pre-pregnancy weight or in early pregnancy (up to 8 weeks). Normal weight: BMI ≥ 18.5 and < 25.0 kg/m^2; Overweight: BMI ≥ 25.0 and < 30.0 kg/m^2.

Abbreviations: GWG: gestational weight gain; SD: standard deviation; SSD: standardized site difference.

Figure 2: Distribution of gestational weight gain of the dataset without *v.* dataset with the exclusion criteria applied for individuals with normal weight: **A:** at 13 weeks; **B:** at 27 weeks; **C:** at 40 weeks.

Notes: Body mass index (BMI) was calculated based on a pre-pregnancy weight or in early pregnancy (up to 8 weeks). Normal weight: BMI ≥ 18.5 and < 25.0 kg/m^2. Vertical lines refer to the predicted 10th and 90th percentiles of the curves generated using quantile regression: lighter lines are the values for the dataset without the application of the criteria and darker lines are for the dataset after the criteria was applied. The latter was created from the larger dataset (n=14,685 individuals and 32,130 GWG measurements), by removing individuals who gave birth to an infant classified as preterm, small-for-gestational-age or large-for-gestational-age, and low birth weight or macrosomia (n = 10,479 individuals and 22,118 GWG measurements).

Figure 3: Distribution of gestational weight gain of the dataset without *v.* dataset with the exclusion criteria applied for individuals with overweight: **A:** at 13 weeks; **B:** at 27 weeks; **C:** at 40 weeks.

Notes: Body mass index (BMI) was calculated based on a pre-pregnancy weight or in early pregnancy (up to 8 weeks). Overweight: BMI ≥ 25.0 and < 30.0 kg/m^2. Vertical lines refer to the predicted 10th and 90th percentiles of the curves generated using quantile regression: lighter lines are the values for the dataset without the application of the criteria and darker lines are for the dataset after the criteria was applied. The latter was created from the larger dataset (n=4,831 individuals and 8,825 GWG measurements), by removing individuals who gave birth to an infant classified as preterm, small-for-gestational-age or large-for-gestational-age, and low birth weight or macrosomia (n = 3,466 individuals and 6,232 GWG measurements).

Figure 4: Comparison of the gestational weight gain trajectories of the dataset without *v.* dataset with the exclusion criteria applied: **A:** Normal weight; **B:** Overweight.

Notes: Body mass index (BMI) was calculated based on a pre-pregnancy weight or in early pregnancy (up to 8 weeks). Normal weight: BMI ≥ 18.5 and < 25.0 kg/m^2; Overweight: BMI ≥ 25.0 and < 30.0 kg/m^2. The dataset with the exclusion criteria applied was created from the larger dataset (normal weight: n=14,685 individuals and 32,130 GWG measurements; overweight: n=4,831 individuals and 8,825 GWG measurements), by removing individuals who gave birth to an infant classified as preterm, small-for-gestational-age or large-for-gestational-age, and low birth weight or macrosomia (normal weight: n = 10,479 individuals and 22,118 GWG measurements; overweight: n = 3,466 individuals and 6,232 GWG measurements).