Original Research

Gestational weight gain recommendations for Chilean women: a mathematical optimization approach

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ABSTRACT

Objectives: We examined if the guidelines for gestational weight gain (GWG) proposed by the Institute of Medicine (IOM) are the most suitable for Chilean women.

Study design: Secondary analysis of records of single full-term births at the Dr. Sótero del Río Hospital, Santiago, Chile, during 2003–2012 ($n = 62,579$).

Methods: From clinical records, we obtained data regarding maternal age, height, pre-pregnancy and at delivery weights, pathologies during pregnancy such as gestational diabetes (GDM) and pre-eclampsia, gestational age at delivery, and number of infants born small for gestational age (SGA) and large for gestational age (LGA). We formulated a mathematical model (MM) to determine the GWG range that maximizes the likelihood of a healthy pregnancy (HP) if the recommendation is followed. We defined an HP as one where the mother has no complications such as pre-eclampsia, GDM, SGA, or LGA.

Results: Forty-six percent of women had prepregnancy overweight or obesity. The prevalence of GDM, pre-eclampsia, SGA, and LGA were 3%, 1.2%, 9%, and 12%, respectively. An HP was present in 76% of pregnancies, 79% in the underweight group, 79% in normal weight group, 74% in the overweight group, and 67% in obese women. The GWG recommendations given by the MM (14–20 kg for underweight, 6–20 kg for normal weight, 9–11 kg for overweight, and 6–7 kg for obese) led to higher probabilities of achieving an HP than the ones obtained with the IOM recommendations.

Conclusion: The adoption of GWG recommendations based on characteristics of the Chilean population might lead to better short- and long-term health results for pregnant women.

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Introduction

Gestational weight gain (GWG) is a natural physiological process that allows for fetal growth and development. It varies significantly among women; approximately 35% of the GWG accounts for gestational products (placenta, fetus, and amniotic fluid).[1] Despite being a physiological process, inappropriate GWG has been associated with adverse health outcomes for the mother and the child. For example, excessive GWG is associated with a higher incidence in gestational diabetes (GDM), pre-eclampsia, eclampsia, cesarean section, and postpartum weight retention (PPWR) in women.[2,3] In terms of adverse outcomes for the descendants, a higher proportion of small for gestational age (SGA) and large for gestational age (LGA) infants, preterm delivery, and childhood obesity has been observed.[3–5] On the other hand, low GWG is associated with a high proportion of SGA infants and preterm birth.[3]

In 2009, the USA Institute of Medicine (IOM) proposed a set of revised guidelines for GWG based on empirical data on the relationship between GWG patterns and adverse outcomes for the mother and child according to prepregnancy nutritional status based on the World Health Organization[6]: 12.5–18 kg for underweight (body mass index [BMI] <18.5 kg/m^2), 11.5–16 kg for normal weight (BMI 18.5–24.9 kg/m^2), 7–11.5 kg for overweight (BMI 25.0–29.9 kg/m^2), and 5–9 kg for obesity (BMI ≥30 kg/m^2).[1]

We propose that the IOM GWG guidelines were developed using the US data, and therefore, they are not necessarily suitable for other populations. Although they have been used in numerous countries,[7] their authors warn that they might not be appropriate for women with a lower than average height or weight compared with those in the US population. They acknowledge that ethnicity might also determine different GWG recommendations. Finally, these guidelines do not distinguish between adolescents (<20 years) and adults within a prepregnancy nutritional status; there is a risk of miscategorizing teenagers in an inappropriate (lower) nutritional status and therefore recommending a much higher GWG than needed by their age group.[1]

Chile has a high incidence of overweight and obesity among child-bearing age women (36% and 28%, respectively),[8] and one-third of pregnant women are obese.[9] Additionally, the average height in women is only 157.2 cm,[8] and teenage pregnancy accounts for 17% of all pregnancies.[10] The Chilean Ministry of Health recommends monitoring the nutritional status during pregnancy based on Atalah's curve, which is based on the intersection of woman's BMI and her gestational age.[11] According to Atalah's curve, the GWG guidelines for Chilean population, at the beginning of the pregnancy, are as follows: 12–18 kg for underweight, 10–13 kg for normal weight, 7–10 kg for overweight, and 6–7 kg for obese women.[12] However, these guidelines were not estimated based on local data linking GWG with perinatal outcomes. In this article, we examine, using an extensive population database, whether the IOM GWG recommendations are suitable for Chilean women or if there are better recommendations using the characteristics of the Chilean population. We also study recommendations stratified by women's age and height.

Methods

Study design and participants

The present study is a secondary analysis of records for all of the single births at the Dr. Sótero del Río Hospital in the southeast public health district of Santiago, Chile, during 2003–2012 (N = 69,976 pregnant women). This sample covers a population of 1,521,144 inhabitants (approximately 9% of the total population of the country), 77% of whom receive care within the public system and closely represent the low- and middle-income Chilean population.[13]

Variables and procedures

We obtained study data from maternity records at Dr. Sótero del Río Hospital. We recorded sociodemographic (age, education) and lifestyle (smoking) characteristics, obstetric and morbid history, maternal data during pregnancy (GDM, pre-eclampsia, eclampsia, and other complications), gestational age at delivery, mode of delivery (caesarean section, vaginal, forceps), and offspring data at birth (height, weight).

Regarding maternal anthropometric indicators, pregestational weight was self-reported by pregnant women. In Chile, as in most countries, it is impractical to weight women just before they become pregnant. Therefore, most of the studies rely on self-reported weights. Fortunately, there is plenty of evidence that prepregnancy self-reported weight strongly correlates with weight measured at the first prenatal hospital visit (study contact).[14,15,16] This has proven to be true even in contexts with lower educational level.[17,18]

Height and weight just before delivery were measured by midwives at the delivery. Prepregnancy BMI was calculated dividing the prepregnancy weight by the squared height (prepregnancy weight [kg]/height [m]^2), and patients were classified as underweight, normal weight, overweight, or obese. GWG was calculated as the difference between weight at delivery and prepregnancy weight and classified as below, within, or above the IOM 2009[1] recommendations. GDM was defined according to Chilean Ministry of Health guidelines (having fasting plasma glucose levels <100 mg/dl or 2-h values in the oral glucose tolerance test of <140 mg/dl at 24–28 weeks of pregnancy).[12,19] Pre-eclampsia was defined as having the following two conditions: (i) the presence of a systolic blood pressure greater than or equal to 140 mm Hg or a diastolic blood pressure greater than or equal to 90 mm Hg or higher, on two occasions at least 4 h apart in a previously normotensive patient and ii) proteinuria (≥300 mg/24 h urine specimen).[20] Additionally, eclampsia is a severe complication of pre-eclampsia. It was defined as new onset of grand mal seizure activity and/or unexplained coma during pregnancy or postpartum in a woman with signs or symptoms of pre-eclampsia.[21]

From birth weight, we estimated the incidence of the following neonatal outcomes: infant macrosomia (birth weight above 4000 g), infant low birth weight (birth weight below 2500 g), infant born LGA (birth weight ≥ 90th centile for gestational age according to Alarcón-Pittaluga curves),[22] and

infant born SGA (birth weight $\leq$ 10th centile for gestational age according to Alarcón-Pittaluga curves).[22]

Statistical analyses

The mean and standard deviation (SD) for quantitative variables, as well as absolute and relative frequencies for categorical variables, were calculated.

We formulated a mathematical model (MM) to determine the range for the optimal GWG, which maximizes the difference in the likelihood of a healthy pregnancy (HP) whether recommendations are followed or not. We defined an HP as one where the mother has no complications such as pre-eclampsia, eclampsia, and GDM and the baby has no SGA or LGA.[3] Thus, if one or more of these problems appeared, then we considered that an unhealthy pregnancy. The main constraints of the model are (i) for sensible results, the probability of an HP if recommendations are not followed has to be lower than a certain threshold established by the decision maker and (ii) mathematical consistency and achievement relationships (See Supporting Information for more details).

For each BMI group, we calculated a 95% confidence interval for the probability of an HP when the IOM and MM recommendations are followed or not. To construct these confidence intervals, we assumed a Bernoulli distribution for having or not having a normal pregnancy.

Ethical aspects

The Ethics Committee at the South East Metropolitan Health Area approved the study. We used secondary data for our analysis. All data were protected, and personal information was anonymized.

Results

From the initial database of 69,976 women, we further excluded 7397 participants according to the following criteria: height more than 200 or less than 130 cm, GWG more than +60 or less than −5 kg, weeks of pregnancy less than 37 (to exclude preterm birth) or more than 42, prepregnancy BMI more than 60 or less than 14 kg/m^2, birth weight more than 500 g, maternal age less than 12 years and/or with incomplete data. The final sample size was 62,579 women, distributed as underweight ($n = 1,333$, 2.1%), normal weight ($n = 32,633$, 52.1%), overweight ($n = 18,571$, 29.7%), and obese ($n = 10,042$, 16.1%).

The general characteristics of the sample are shown in Table 1. The average age of the participants was 26 years (SD = 7.0) with an average prepregnancy BMI of 25.5 kg/m^2 (SD = 4.7). The prevalence of GDM, pre-eclampsia, SGA, and LGA were 3%, 1.2%, 9.1%, and 12%, respectively. This prevalence was higher in women with prepregnancy obesity. When considering eclampsia, pre-eclampsia, GDM, and inadequate birth weight as undesirable outcomes, an HP was present in 76% of the sample; 79% in the group of underweight, 79% in normal weight, 74% in overweight, and 67% in obese women.

Table 2 shows the GWG ranges for each prepregnancy nutritional status that maximizes the probability of having an

HP (α) according to the MM together with the range recommended by the IOM. The range of GWG obtained by the MM was 14–20 kg for underweight, 6–20 kg for normal weight, 9–11 kg for overweight, and 6–7 kg for obese. We observed that for every prepregnancy nutritional status, the optimal GWG recommendations obtained by the MM led to larger differences between α and β (the probability of having an HP when not complying with the recommendations) compared with those obtained when using the IOM recommendations. We also noticed the highest difference between α and β in the group of underweight women, and therefore, women with lower pregestational nutritional status seemed to benefit more when following our recommendations.

We also ran the MM to determine the optimal recommendations for women younger and older than the age of 20 years (Table 3) and less and more than the average Chilean height of 157 cm (Table 4).

For women aged 20 years and older, there are no benefits from segmenting by age. In fact, GWG recommendations remained unchanged, except for a small change of 1.4 kg in the underweight category (Table 3). However, for women younger than 20 years, the probability of having an HP improved by 5.2%, 3.9%, and 11.2% for underweight, normal, and obese respectively. We propose that the number of women who benefit from this refined classification of younger than 20 years represents approximately 20% of the general population. However, within the underweight group, it corresponds to 43.8%, corresponding to the pregestational BMI group with the highest proportion of teenagers. We also noticed that because the number of women younger than 20 years is relatively small in some groups (812 of 10,042 in the obese group), the confidence intervals for the probability of having a normal pregnancy are large and overlap those when using a single interval with no age segmentation.

We observed, from Table 4, that the benefits obtained from height segmentation are modest. In all cases, the probability of an HP when following the recommendations given for each height segment (α) improved in less than 1% compared with the cases when using the recommendations by segmenting solely by prepregnancy nutritional groups. The only exception is for the subgroup of obese women with height larger than or equal to 1.57 m, where the probability of having an HP increases from 71.0% to 72.4% when segmenting by height. Furthermore, for the case of normal pregestational BMI, the recommendations when segmenting by height remained unchanged.

Discussion

In this study, we developed GWG recommendations adapted for the Chilean population using a database of approximately 63,000 women, which was representative of medium to low socio-economic status in Santiago, Chile. We compared the GWG range recommended by the 2009 IOM guidelines with those obtained using an optimization model, considering an 'HP' as the absence of five adverse outcomes: pre-eclampsia, eclampsia, GDM, SGA, and LGA. Our results confirm that GWG recommendations given by the optimization model perform better than those suggested by the IOM in terms of

Prepregnancy nutritional status (kg/m^2)	N	%	Age (years)		Height (m)		GWG (kg)		Pregestational BMI (kg/m^2)		BW (gr)		PC	EC	GDM	SGA	LGA	HP
			Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	%	%	%	%	%	%
Underweight (BMI <18.5 kg/m^2)	1333	2.1	21.4	(5.1)	1.59	(0.06)	16.3	(6.0)	17.9	(0.5)	3233	(398)	0.5	0.00	0.9	15.5	4.6	79.1
<20 years	584	43.8	17.4	(1.4)	1.58	(0.05)	16.3	(5.5)	17.9	(0.5)	3234	(376)	1.0	0.00	0.7	13.2	3.6	81.8
≥20 years	749	56.2	24.6	(4.6)	1.59	(0.07)	16.4	(6.4)	17.8	(0.6)	3233	(414)	0.0	0.00	1.1	17.4	5.3	76.9
<1.57 m	504	37.8	21.9	(5.7)	1.53	(0.03)	15.9	(5.9)	17.9	(0.5)	3161	(413)	0.4	0.00	1.6	20.6	3.6	74.6
≥1.57 m	829	62.2	21.1	(4.6)	1.62	(0.05)	16.6	(6.0)	17.8	(0.6)	3277	(382)	0.5	0.00	0.5	12.4	5.2	81.8
Normal weight (BMI 18.5–24.9 kg/m^2)	32,633	52.1	24.2	(6.6)	1.58	(0.06)	15.1	(5.8)	22.3	(1.7)	3359	(420)	0.9	0.01	1.4	10.6	8.7	79.1
<20 years	9203	28.2	17.4	(1.4)	1.57	(0.06)	15.5	(6.0)	21.9	(1.7)	3329	(405)	1.1	0.01	0.3	11.6	6.5	80.9
≥20 years	23,430	71.8	26.9	(5.8)	1.58	(0.06)	14.9	(5.8)	22.4	(1.6)	3371	(425)	0.9	0.01	1.8	10.2	9.6	78.3
<1.57 m	14,292	43.8	24.5	(6.9)	1.52	(0.03)	14.4	(5.6)	22.4	(1.6)	3296	(407)	0.9	0.01	1.6	13.0	6.5	78.7
≥1.57 m	18,341	56.2	24.0	(6.3)	1.62	(0.04)	15.6	(6.0)	22.2	(1.7)	3409	(424)	0.9	0.01	1.2	8.7	10.5	79.3
Overweight (BMI 25.0–29.9 kg/m^2)	18,571	29.7	27.4	(7.0)	1.57	(0.06)	13.2	(6.6)	27.2	(1.4)	3471	(455)	1.3	0.00	3.4	7.6	14.9	74.3
<20 years	2581	13.9	17.6	(1.4)	1.58	(0.06)	14.4	(7.3)	26.9	(1.4)	3394	(424)	2.2	0.00	0.7	10.3	8.9	78.7
≥20 years	15,990	86.1	29.0	(6.2)	1.57	(0.06)	13.0	(6.5)	27.2	(1.4)	3483	(459)	1.1	0.00	3.8	7.2	15.9	73.6
<1.57 m	8337	44.9	28.1	(7.2)	1.52	(0.03)	12.6	(6.2)	27.2	(1.4)	3405	(450)	1.4	0.00	4.2	9.6	11.7	74.8
≥1.57 m	10,234	55.1	26.9	(6.8)	1.62	(0.04)	13.7	(6.9)	27.1	(1.4)	3525	(452)	1.2	0.00	2.7	6.0	17.5	73.8
Obese (BMI > 30 kg/m^2)	10,042	16.0	28.7	(6.7)	1.57	(0.06)	10.1	(7.0)	33.7	(3.4)	3537	(474)	2.1	0.05	7.1	6.2	20.6	67.4
<20 years	812	8.1	17.8	(1.3)	1.58	(0.06)	11.0	(8.0)	32.9	(2.7)	3451	(463)	2.5	0.12	1.1	10.1	13.3	73.9
≥20 years	9230	91.9	29.7	(6.1)	1.57	(0.06)	10.0	(6.9)	33.8	(3.4)	3545	(474)	2.1	0.04	7.6	5.8	21.2	66.8
<1.57 m	4692	46.7	29.6	(6.8)	1.52	(0.04)	9.6	(6.7)	33.9	(3.4)	3483	(474)	1.8	0.06	8.3	7.6	17.4	68.6
≥1.57 m	5350	53.3	27.9	(6.5)	1.61	(0.04)	10.5	(7.3)	33.6	(3.3)	3585	(469)	2.4	0.04	6.0	4.9	23.4	66.2
Total	62,579	100.0	25.8	(7.0)	1.57	(0.06)	13.7	(6.5)	25.5	(4.7)	3418	(445)	1.2	0.01	2.9	9.1	12.4	75.8

Table 1 – Characteristics of study population.

BMI, body mass index; GWG, gestational weight gain; BW, birth weight; PC, preeclampsia; EC, eclampsia; GDM, gestational diabetes; SGA, small for gestational age; LGA, large for gestational age; HP, healthy pregnancy; SD, standard deviation.

Table 2 – Comparison of gestational weight gain recommendations: 2009 IOM vs mathematical model (MM).

Prepregnancy nutritional status (N)	Source	GWG range (kg)	N within GWG range	α (%)	Confidence interval α (%)	B (%)	Confidence interval β (%)	α-β (%)
Underweight (n=1333)	MM	[14−20]	639	83.1	[79.7−86.6]	75.4	[71.6−79.2]	7.7
	IOM	[12−18]	708	81.5	[79.2−84.0]	76.3	[73.6−79.2]	5.2
Normal weight (n=32,633)	MM	[6−20]	26,513	79.9	[79.3−80.5]	75.4	[74.2−76.7]	4.4
	IOM	[11−16]	14,111	80.3	[79.7−80.8]	78.1	[77.6−78.6]	2.1
Overweight (n=18,571)	MM	[9−11]	3425	77.7	[76.1−79.4]	73.5	[72.6−74.3]	4.2
	IOM	[7−11]	5048	77.1	[76.1−78.0]	73.2	[72.6−73.8]	3.8
Obesity (n=10,042)	MM	[6−7]	1025	72.2	[69.0−75.5]	66.8	[65.7−68.0]	5.4
	IOM	[5−9]	2548	70.0	[68.5−71.5]	66.5	[65.6−67.4]	3.5

GWG, gestational weight gain; IOM, Institute of Medicine.
α: probability of having a healthy pregnancy, when complying with the recommendations, β: probability of having a healthy pregnancy, when not complying with the recommendations, α-β: gap between following or not following the GWG recommendations.
MM: GWG range (kg) according a mathematical model considering a healthy pregnancy as the absence of preeclampsia, eclampsia, gestational diabetes, SGA, and LGA.
IOM: Institute of Medicine 2009 GWG range guidelines.

Table 3 – Gestational weight gain recommendations according to the mathematical model stratified by age.

Prepregnancy nutritional status (N)	GWG range (kg) according to MM	N within GWG range	α (%)	Confidence interval α (%)	β (%)	Confidence interval β (%)	α-β (%)
Underweight (n=1333)							
<20 years (n = 584), MMA	[16−17]	83	88.0	[80.2−96.9]	80.8	[76.8−85.0]	7.1
<20 years (n = 584), MM	[14−20]	267	82.8	[77.6−88.3]	81.1	[76.1−86.3]	1.7
≥20 years (n = 749), MMA	[13−20]	424	83.0	[78.9−87.4]	68.9	[63.1−75.0]	14.1
≥20 years (n = 749), MM	[14−20]	372	83.3	[79.0−88.0]	70.6	[65.2−76.2]	12.8
Normal weight (n=32,633)							
<20 years (n = 9203), MMA	[17−18]	1143	85.6	[83.2−88.0]	80.2	[79.2−81.3]	5.3
<20 years (n = 9203), MM	[6−20]	7200	81.7	[80.7−82.8]	77.9	[75.8−80.1]	3.8
≥20 years (n = 23,430), MMA	[6−20]	19,313	79.2	[78.5−79.9]	74.2	[72.7−75.8]	5.0
≥20 years (n = 23,430), MM	[6−20]	19,313	79.2	[78.5−79.9]	74.2	[72.7−75.8]	5.0
Overweight (n=18,571)							
<20 years (n = 2581), MMA	[9−12]	482	84.4	[80.7−88.4]	77.3	[75.2−79.5]	7.1
<20 years (n = 2581), MM	[9−11]	359	84.7	[80.4−89.2]	77.7	[75.6−79.8]	7.0
≥20 years (n = 15,990), MMA	[9−11]	3066	76.9	[75.2−78.7]	72.8	[71.8−73.7]	4.2
≥20 years (n = 15,990), MM	[9−11]	3066	76.9	[75.2−78.7]	72.8	[71.8−73.7]	4.2
Obesity (n=10,042)							
<20 years (n = 812), MMA	[7−9]	98	84.7	[76.7−93.7]	72.4	[68.6−76.4]	12.3
<20 years (n = 812), MM	[6−7]	68	73.5	[61.8−86.7]	73.9	[70.2−77.7]	−0.4
≥20 years (n = 9230), MMA	[6−7]	957	72.1	[68.8−75.5]	66.2	[65.0−67.4]	5.9
≥20 years (n = 9230), MM	[6−7]	957	72.1	[68.8−75.5]	66.2	[65.0−67.4]	5.9

MM, mathematical model; GWG, gestational weight gain; MMA, mathematical model stratified by age.
α: probability of having a healthy pregnancy, when complying with the recommendations, β: probability of having a healthy pregnancy, when not complying with the recommendations, α-β: gap between following or not following the GWG recommendations.
MMA: GWG range (kg) according a mathematical model considering a healthy pregnancy as the absence of preeclampsia, eclampsia, gestational diabetes, SGA, and LGA, stratifying by nutritional category and age.
MM: GWG range (kg) according a mathematical model considering a healthy pregnancy as the absence of preeclampsia, eclampsia, gestational diabetes, SGA, and LGA, stratifying by nutritional category.

the gap between the probability of an HP when following or not following the recommendations.

We also found that GWG recommendations obtained with the optimization model differ as a function of the prepregnancy nutritional status, which is consistent with the 2009 IOM guidelines and with other recommendations in several countries.[1,7] Our findings using the model showed that GWG ranges were tighter than those of the IOM guidelines in the groups of overweight and obese women: 14−20 kg for underweight, 6−20 kg for normal weight, 9−11 kg for overweight, and 6−7 kg for obesity. We conclude that the gap in the probability of an HP when following or not following these recommendations goes from 8% for underweight, 4% for normal and overweight, and 5% for obese compared with 5%, 2%, 4%, and 4%, respectively, for the IOM guidelines.[1] We also observe that the most significant benefits are obtained for underweight and normal weight women. We believe that this is an important difference, given that pregnant women will tend to comply with recommendations proposed by the health system. Therefore, if women are advised to gain less weight, this will lower the risk of PPWR and its future complications.

Table 4 – Gestational weight gain recommendations according to the mathematical model stratified by height.

Prepregnancy nutritional status (N)	GWG range (kg) according to MM	N within GWG range	α (%)	Confidence interval α (%)	β (%)	Confidence interval β (%)	α-β (%)
Underweight (n = 1333)							
<1.57 m (n = 504), MMH	[12−20]	336	76.8	[71.6−82.3]	70.2	[62.3−78.7]	6.5
<1.57 m (n = 504), MM	[14−20]	251	76.5	[70.5−82.9]	72.7	[66.4−79.4]	3.8
≥1.57 m (n = 829), MMH	[14−20]	388	87.4	[83.6−91.4]	76.9	[72.3−81.7]	10.5
≥1.57 m (n = 829), MM	[14−20]	388	87.4	[83.6−91.4]	76.9	[72.3−81.7]	10.5
Normal weight (n=32,633)							
<1.57 m (n = 14,292), MMH	[6−20]	12,022	79.4	[78.6−80.3]	74.8	[72.7−76.9]	4.7
<1.57 m (n = 14,292), MM	[6−20]	12,022	79.4	[78.6−80.3]	74.8	[72.7−76.9]	4.7
≥1.57 m (n = 18,341), MMH	[6−20]	14,491	80.3	[79.5−81.0]	75.8	[74.3−77.5]	4.4
≥1.57 m (n = 18,341), MM	[6−20]	14,491	80.3	[79.5−81.0]	75.8	[74.3−77.5]	4.4
Overweight (n=18,571)							
<1.57 m (n = 8337), MMH	[7−19]	6088	76.0	[74.7−77.3]	71.7	[69.5−74.0]	4.3
<1.57 m (n = 8337), MM	[9−11]	1673	77.5	[75.1−79.9]	74.2	[72.9−75.4]	3.3
≥1.57 m (n = 10,234), MMH	[5−12]	3669	77.6	[76.0−79.2]	71.7	[70.4−73.0]	5.9
≥1.57 m (n = 10,234), MM	[9−11]	1752	78.0	[75.7−80.3]	72.9	[71.8−74.1]	5.0
Obesity (n=10,042)							
<1.57 m (n = 4692), MMH	[9−10]	545	73.8	[69.5−78.2]	68	[66.3−69.7]	5.8
<1.57 m (n = 4692), MM	[6−7]	512	73.4	[69.0−78.1]	68	[66.4−69.7]	5.4
≥1.57 m (n = 5350), MMH	[7−8]	579	72.4	[68.1−76.8]	65.5	[63.9−67.1]	6.9
≥1.57 m (n = 5350), MM	[6−7]	513	71.0	[66.4−75.7]	65.7	[64.2−67.3]	5.2

MM, mathematical model; GWG, gestational weight gain; MMH, mathematical model stratified by height.
α: probability of having a healthy pregnancy, when complying with the recommendations, β: probability of having a healthy pregnancy, when not complying with the recommendations, α-β: gap between following or not following the GWG recommendations.
MMH: GWG range (kg) according a mathematical model considering a healthy pregnancy as the absence of preeclampsia, eclampsia, gestational diabetes, SGA, and LGA, stratifying by nutritional category and height.
MM: GWG range (kg) according a mathematical model considering a healthy pregnancy as the absence of preeclampsia, eclampsia, gestational diabetes, SGA, and LGA, stratifying by nutritional category.

Our results for the Chilean population differ from the IOM guidelines, which are mainly based on the Caucasian population, and from those found in Asian populations.[23,24] The differences with the Caucasian and Asian populations could be explained by ethnic factors associated with GWG, such as maternal height, fat deposition, and/or pelvic shape.[25,26] For example, in our analysis, obese Chilean women may gain less gestational weight than that the IOM 2009 guidelines recommend without increasing their risk of adverse perinatal outcomes. Additionally, we remark that our methodology for calculating optimal GWG ranges differed from the one used to establish the IOM 2009 guidelines. We determined the optimal GWG ranges by using an MM, where an HP is defined by a composite of maternal and neonatal outcomes, commonly used in the literature.

We also assessed the optimal GWG values by age and height groups to evaluate if these might differ with respect to the combined values. While there is a benefit in achieving an HP and adopting specific GWG recommendations in the group of underweight and normal weight adolescent women, the results showed modest differences in the rest of the stratified analyses. However, given the relatively small number of women younger than the age of 20 years in our sample, their estimates should be interpreted with caution. Therefore, recommendations using only pregestational nutritional status lead to almost optimal results and are much easier to implement and follow in practice. Segmenting by age and/or height would introduce an unnecessary degree of difficulty with negligible benefits.

We propose that although IOM recommendations could be used for the Chilean population, these were designed for

women in the United States, and therefore, a significant improvement can be obtained by redefining the ranges using Chilean data. These adjusted GWG recommendations obtained using the Chilean population can be of great importance, especially when these are under revision by the Ministry of Health.

Our study is not without limitations. First, our database consists of secondary information, and therefore, there could be either errors or subreporting information regarding pathologies; outliers were discarded. Second, prepregnancy weight was self-reported; however, as previously discussed, self-reported weight has been widely validated in comparison to measured weight.[14−17,27] Finally, in the composite measure for HP, all factors had the same weight, and it is possible that GWG affects the birth weight more significantly compared with the impact on GDM and pre-eclampsia. However, there are no recommendations in the literature to improve this assumption. The most important strength of this study is the use of an extensive database from the largest public hospital in Chile, and therefore, the recommendations obtained can be extrapolated to the low/medium socio-economic Chilean population.

The adoption of GWG recommendations based on the characteristics of the Chilean population might lead to better short- and long-term health results for pregnant women. We believe that the success of these new recommendations depends on public policies that help women to comply with them. If these new recommendations were implemented in practice, a follow-up would be needed to confirm whether these are the most suitable for Chilean pregnant women and

thus give consistency to these findings. We emphasize that the success of implementing GWG recommendations relies heavily on programs designed by the public health system to educate and incentivize pregnant women to comply with them.

Author statements

Ethical approval

The Ethics Committee at the South East Metropolitan Health Area approved the study. We used secondary data for our analysis. All data were protected, and personal information was anonymized.

Competing interests

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