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## 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, prepregnancy 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).<sup>1</sup> 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.<sup>2,3</sup> 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.<sup>3–5</sup> On the other hand, low GWG is associated with a high proportion of SGA infants and preterm birth.<sup>3</sup>

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<sup>6</sup>: 12.5–18 kg for underweight (body mass index [BMI] <18.5 kg/m<sup>2</sup>), 11.5–16 kg for normal weight (BMI 18.5–24.9 kg/m<sup>2</sup>), 7–11.5 kg for overweight (BMI 25.0–29.9 kg/m<sup>2</sup>), and 5–9 kg for obesity (BMI ≥30 kg/m<sup>2</sup>).<sup>1</sup>

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,<sup>7</sup> 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.<sup>1</sup>

Chile has a high incidence of overweight and obesity among child-bearing age women (36% and 28%, respectively),<sup>8</sup> and one-third of pregnant women are obese.<sup>9</sup> Additionally, the average height in women is only 157.2 cm,<sup>8</sup> and teenage pregnancy accounts for 17% of all pregnancies.<sup>10</sup> 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.<sup>11</sup> 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.<sup>12</sup> 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.<sup>13</sup>

### 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, prepregnancy weight was self-reported by pregnant women. In Chile, as in most countries, it is impractical to weigh 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).<sup>14,15,16</sup> This has proven to be true even in contexts with lower educational level.<sup>17,18</sup>

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 (pregnancy weight [kg]/height [m]<sup>2</sup>), 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<sup>1</sup> 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).<sup>12,19</sup> 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).<sup>20</sup> 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.<sup>21</sup>

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),<sup>22</sup> and

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