Health Care for Women International

ISSN: 0739-9332 (Print) 1096-4665 (Online) Journal homepage: http://www.tandfonline.com/loi/uhcw20

Predictors of gestational weight gain among Chilean pregnant women: The Chilean Maternal and Infant Nutrition Cohort study

Maria Luisa Garmendia, Susana Mondschein, Omar Matus, Ruth Murrugarra & Ricardo Uauy

To cite this article: Maria Luisa Garmendia, Susana Mondschein, Omar Matus, Ruth Murrugarra & Ricardo Uauy (2017) Predictors of gestational weight gain among Chilean pregnant women: The Chilean Maternal and Infant Nutrition Cohort study, Health Care for Women International, 38:8, 892-904, DOI: 10.1080/07399332.2017.1332627

To link to this article: https://doi.org/10.1080/07399332.2017.1332627

Accepted author version posted online: 19 May 2017.
Published online: 22 Jun 2017.

HEALTH CARE FOR WOMEN INTERNATIONAL
2017, VOL. 38, NO. 8, 892–904
https://doi.org/10.1080/07399332.2017.1332627

Taylor & Francis
Taylor & Francis Group

Check for updates

Predictors of gestational weight gain among Chilean pregnant women: The Chilean Maternal and Infant Nutrition Cohort study

Maria Luisa Garmendia[a], Susana Mondschein[b], Omar Matus[b], Ruth Murrugarra[b], and Ricardo Uauy[a]

[a]Institute of Nutrition and Food Technology, University of Chile, Santiago, Chile; [b]Facultad de Ingeniería y Ciencias, Universidad Adolfo Ibañez, Santiago, Chile

ABSTRACT
We identified factors associated with gestational weight gain (GWG) in 1,654 Chilean pregnant women with full-term pregnancies. At baseline, we collected information about sociodemographic, gyneco-obstetric, anthropometric, and health-care-related factors. We found that prepregnancy nutritional body mass index was the most important factor related to GWG above recommendations (overweight: ratio of relative risks [RRR] = 2.31, 95% confidence interval [CI, 1.73, 3.09] and obesity: RRR = 2.90, 95% CI [2.08, 4.03]). We believe that women who are overweight/obese at the beginning of pregnancy should be identified because of their higher risk, and that adequate strategies should be designed and implemented to help them achieve a healthy GWG.

ARTICLE HISTORY
Received 22 December 2016
Accepted 16 May 2017

In the present study, we evaluated sociodemographic, gyneco-obstetric, anthropometric, and health-care-related factors that influence gestational weight gain (GWG) in a Chilean population of pregnant women of low and medium socioeconomic levels. Efforts have been made in Chile to not only reduce prepregnancy obesity to go through pregnancy under optimal conditions but also promote healthy GWG to minimize medical complications for the baby and mother during this pregnancy. Although Chile is a developed country, there are high economic and social disparities. Because of these factors, together with the rapid nutritional transition over the past years and Chile's ethnic and cultural specificities, we believe that it is unclear if GWG recommendations for developed countries can be applied to the Chilean population and others with similar characteristics. We think that understanding the predictors associated with GWG is important for identifying at-risk women and for designing interventions to help mothers avoid adverse outcomes.

CONTACT Maria Luisa Garmendia mgarmendia@inta.uchile.cl Institute of Nutrition and Food Technology, University of Chile, El Líbano 5524, Santiago, Chile.

Several investigators have documented that prepregnancy obesity (body mass index [BMI] prior to pregnancy $\geq$ 30 kg/m^2) represents a major public health challenge because it affects not only the health of the women but also that of the offspring (Leddy, Power, & Schulkin, 2008). They have shown that prepregnancy obesity is a risk factor for adverse pregnancy complications (gestational diabetes mellitus and preeclampsia), obstetric complications (cesarean delivery), neonatal complications (macrosomia and large-for-gestational-age infants), and long-term outcomes (obesity and noncommunicable diseases in the baby) (Nelson, Matthews, & Poston, 2009; O'Reilly & Reynolds, 2013). GWG below or above recommendations has also been associated with adverse health effects. In 2009, the Institute of Medicine (IOM) of the United States published revised GWG guidelines based on prepregnancy BMI categories (Institute of Medicine & National Research Council, 2009). These guidelines recommend a range for GWG based on prepregnancy BMI: underweight (BMI < 18.5 kg/m^2: 12.5–18.0 kg), normal weight (BMI $\geq$ 18.5–24.9 kg/m^2: 11.5–16.0 kg), overweight (BMI 25.0–29.930.0 kg/m^2: 6.8–11.3 kg), and obese (BMI $\geq$ 30.0 kg/m^2: 5.0–9.0 kg). GWG above recommendations has been shown to be associated with fetal death and gestational diabetes, macrosomia, preeclampsia, and complicated deliveries in the mother (Norman & Reynolds, 2011). GWG below recommendations has been shown to be associated with small-for-gestational-age fetuses, low birth weight, and preterm birth (Poston, 2012).

Previous researchers have described many factors influencing GWG such as prepregnancy BMI, maternal age, height, parity, ethnicity, educational level, marital status, and number of midwife visits (Campbell et al., 2016; Samura et al., 2016). However, most of these investigators based their results on populations from developed Western countries, and therefore, their conclusions might not be applicable to countries with different characteristics, such as ethnic composition, social inequalities, and speed of nutritional transition. For example, researchers from Brazil showed that GWG below recommendations was associated with low educational level and that GWG above recommendations was related to prepregnancy nutritional BMI and high blood pressure (Fraga & Theme Filha, 2014).

In 2010, the Organization for Economic Cooperation and Development (OECD) incorporated Chile as a member and as the first country in Latin America (OECD, 2010). Although this signifies a relatively high income per capita, the level of economic and social inequalities in Chile is the highest among the current 35 members of this organization (OECD, 2015). In addition, the nutritional status in Chile is comparable to that in countries such as the United States; Chile has undergone rapid nutritional transition, and the prevalence of gestational obesity (Atalah, Castillo, Castro, & Aldea, 1997; Atalah & Castro, 2004) has increased from 20% in 2005 to 30% in 2015 (Araya, Padilla, Garmendia, Atalah, & Uauy, 2014; Government of Chile, Ministry of Health, 2015). We strongly believe that these distinctive characteristics might lead to GWG recommendations that differ from those in developed countries.

Together with the design and implementation of policies to reduce prepregnancy obesity for women to face pregnancy with a normal nutritional status, we believe that it is equally important to design strategies to promote healthy GWG. The latter results in better health outcomes for the baby and mother and relates to the initial health status for future pregnancies.

Methods

Setting and database

Our study is a secondary analysis of the Chilean Maternal and Infant Nutrition Cohort study (CHiMINCs). The objective and methods of the CHiMINCs are published elsewhere (Garmendia et al., 2015). Briefly, the CHiMINC investigators aimed to assess the effectiveness of an intervention that enhances the implementation of updated nutrition health care standards (diet, physical activity, and breastfeeding promotion) during pregnancy on maternal GWG and infant growth through a randomized controlled trial. The cluster units were 12 primary health care centers (PHCCs) from two counties (La Florida and Puente Alto) from the Southeast Area of Santiago, Chile, that were randomly allocated to (a) enhanced nutrition health care standards (intervention group) or (b) routine care (control group). We invited each of the 12 PHCCs to participate in the study using regular health service procedures. Randomization was done prior to recruitment of participants. All pregnant women who attended these PHCCs and fulfilled enrollment criteria were invited to participate by the PHCCs' midwives; inclusion criteria were checked by the study field workers and informed consent was obtained from those who expressed an interest in joining the study. A total of 4781 pregnant women were recruited between January 2014 and April 2015. Women of ages between 16 and 40 years at less than 15 weeks of gestation, who did not reside within the catchment area of selected PHCCs and had no plan to move for 2 years, were recruited. Women with high-risk pregnancies according to the guidelines of the Chilean Ministry of Health were excluded. Retention rate was 81%.

Pregnant women who went to the PHCCs allocated for intervention starting on their first midwife visit received advice regarding optimal weight gain during pregnancy and counseling regarding diet and physical activity. Pregnant women who attended the control PHCCs received routine prenatal care according to national guidelines.

For the present study, we used the database of pregnant women recruited in the control group of CHiMINCs to avoid the possible effect of intervention on the predictors of GWG.

Outcome variable

In the present study, we calculated GWG as the difference between delivery and prepregnancy weights, and studied both as continuous variables (kg) and classified them into three categories defined as below, within or above the 2009 IOM guidelines (Institute of Medicine & National Research Council, 2009).

Predictor variables

As potential predictors of GWG, we evaluated sociodemographic, gyneco-obstetric, anthropometric, and health care factors. The sociodemographic variables included the following: maternal age at recruitment (adolescents [<20 years] or adults [20 years or more]), education status (<12 years or ≥12 years), civil status (married/with partner or single/divorced/widow), county of residence (La Florida or Puente Alto), and socioeconomic status (SES) of the population going to PHCCs (high/medium SES: ≥79% finished primary education or low SES: ≤78% finished primary education). The gyneco-obstetric variable included parity (0; 1; 2; or more). The anthropometric variables included height (<158 cm or ≥158 cm) and prepregnancy BMI (underweight, normal, overweight, and obese). The health-care-related variables considered the number of midwife visits (<6 or ≥6) and referral to dietitian (yes/no) during pregnancy.

Data collection

We collected all data as part of routine health care activities. Authorities of PHCCs that participated in our study had implemented electronic health records since 2009. We obtained data related to predictor variables from health records and by direct questioning at recruitment. Weight and height were measured at the first midwife visit, and thereafter, weight was measured during each following midwife visit until delivery.

Data analysis

We started with a database of 2365 women from which we excluded 585 women for whom we did not have prepregnancy BMI data or information about delivery (gestational age, mode of delivery, and weight at delivery) or who had at least one midwife visit during pregnancy. Because GWG is affected by gestational age, we further excluded 126 women who did not give birth at full term (less than 37 weeks), resulting in a total of 1654 women classified as follows: *underweight* (BMI < 18.5 kg/m^2; 38 women), *normal weight* (BMI 18.5–24.9 kg/m^2; 683 women), *overweight* (BMI 25.0–29.9 kg/m^2; 543 women), and *obese* (BMI ≥ 30 kg/m^2; 390 women).

We first carried out a descriptive analysis including the mean and standard deviation for quantitative variables and absolute and relative frequencies for categorical variables. We tested significant differences by predictor variables among groups (GWG above, within, and below IOM recommendations) using χ^2 test (p-value). To compute predictors of GWG, we used crude and adjusted linear and multinomial logistic regression models. In the linear regression models, we considered

GWG as a continuous variable and computed beta-coefficients and 95% confidence intervals (CIs). In the multinomial regression models, we considered three categorical outcomes: (a) GWG below IOM recommendations; (b) GWG within IOM recommendations; and (c) GWG above IOM recommendations. The multinomial logistic regression model is a simple extension of the binomial logistic regression model. It is used when the dependent variable has more than two nominal categories; thus, the dependent variable is dummy coded into multiple 1/0 variables (Long & Freese, 2006) (Hosmer & Lemeshow, 2000). With this model, we estimate a separate binary logistic regression model for each of those dummy variables. Each binary logistic regression model demonstrates the effect of the predictors on the probability of success in that category in comparison with the reference category. In our model, we defined the group with GWG within IOM recommendations as the reference group. We computed the ratio of relative risks (RRR) such that the ratio of probabilities—the probability of being above or below IOM recommendations over the probability of being within IOM recommendations—is referred to as relative risk; exponentiated regression coefficients are thus interpreted as relative risk ratios for a unit change in the predictor variable (Institute for Digital Research and Education UCLA, 2017). We conducted statistical analyses using the R statistical software package version 3.2.4 and Stata 12.0.

Ethical aspects

The CHiMINCs' protocol was approved by the Institutional Review Boards of Institute of Nutrition and Food Technology of University of Chile, the Catholic University of Chile, and the South-Eastern Health Service. All women signed informed consent to participate in the study.

Results

In our analysis, we found that the mean age of pregnant women was 25.8 years ($SD = 6.2$), most of the women were single (53%), had at least 12 years of education (66%), and were primipara (56%) (Table 1). We observed that more than half of the women had a prepregnancy BMI higher than 25 kg/m^2, with 34% of them being overweight and 24% being obese. The mean GWG of women at delivery was 12.9 kg ($SD = 6.3$)—13.6 kg for underweight ($SD = 7.4$), 14.1 for normal ($SD = 5.6$), 12.7 ($SD = 6.6$) for overweight and 10.7 ($SD = 5.4$) for obese women. Approximately 68% of the women did not reach the IOM recommendations—23.9% being below and 43.6% being above the IOM guidelines in the overall population (Table 2). According to the prepregnancy BMI, we found that the percentage of women with GWG below IOM recommendations was 50%, 33%, 16%, and 15% for underweight, normal, overweight, and obese women, respectively. The percentage of women with GWG above IOM recommendations was 22%, 30%, 53%, and 57% for underweight, normal, overweight, and obese women, respectively ($p < .05$) (Table 2).

Table 1. General characteristics of the study population ($n = 1654$).

Variables	*n*/Mean	%/*SD*
Sociodemographic		
Age		
Continuous, years (mean, *SD*)	25.8	6.2
< 20	314	19.1
≥ 20	1331	80.9
Education, y		
< 12	581	34.0
≥ 12	1127	66.0
Civil status		
Married/with partner	748	45.8
Single/divorced/widow	884	54.2
County of residence		
Puente Alto	1272	76.9
La Florida	382	23.1
Public health care center socioeconomic status		
High/medium	924	55.9
Low	730	44.1
Anthropometric		
Prepregnancy BMI		
Continuous, kg/m^2 (mean, *SD*)	26.7	5.3
Underweight, < 18.5	38	2.2
Normal weight, 18.5–24.9	683	41.3
Overweight, 25–29.9	543	33.8
Obesity, ≥ 30	390	23.6
Height		
Continuous, cm (mean, *SD*)	158.1	5.9
≤ 158	875	52.9
> 158	779	47.1
Obstetrics		
Parity (number of children)		
Continuous (mean, *SD*)	0.7	1.0
0 (primigesta)	913	56.0
1	404	24.8
2 or more	314	19.3
Health care		
Prenatal midwife visits, y		
Continuous (mean, *SD*)	5.4	2.9
< 6	902	54.5
6 or more	752	45.5
Referral to dietitian		
Continuous (mean, *SD*)	0.2	0.5
Yes	309	18.7
No	1345	81.3

We observed that the highest GWG occurred in the third trimester of the pregnancy (6.8 kg on average, compared to 2.4 and 4.6 kg in the first and second trimesters, respectively) without differences in prepregnancy BMI (data not shown). We also found that GWG up to the end of the second trimester was a strong predictor of overall GWG in women; the lower the GWG of pregnant women by the end of the second trimester, the higher the probability of reaching IOM recommendations ($p < .05$).

In adjusted models, we found that predictors of lower GWG, when considered as continuous variables, were excess prepregnancy weight (overweight and obesity) compared to normal prepregnancy weight ($p < .05$). We also observed that taller women had a higher GWG compared to shorter women (Table 3). Regarding

Table 2. Gestational weight gain according to prepregnancy body mass index ($n = 1654$).

Variables	N /mean	% / *SD*
GWG, kg, mean (*SD*)		
Total sample	12.9	6.2
Underweight, prepregnancy BMI < 18.5 kg/m^2	13.6	7.4
Normal weight, prepregnancy BMI 18.5–24.9 kg/m^2	14.1	5.6
Overweight, prepregnancy BMI 25–29.9 kg/m^2	12.7	6.6
Obesity, prepregnancy BMI ≥ 30 kg/m^2	10.7	5.4
GWG below IOM recommendations, *n* (%)		
Total sample	395	23.9
Underweight, prepregnancy BMI < 18.5 kg/m^2	19	50.0
Normal weight, prepregnancy BMI 18.5–24.9 kg/m^2	227	33.2
Overweight, prepregnancy BMI 25–29.9 kg/m^2	89	16.4
Obesity, prepregnancy BMI ≥ 30 kg/m^2	59	15.1
GWG above IOM recommendations, *n* (%)		
Total sample	721	43.6
Underweight, prepregnancy BMI < 18.5 kg/m^2	8	22.1
Normal weight, prepregnancy BMI 18.5–24.9 kg/m^2	208	30.4
Overweight, prepregnancy BMI 25–29.9 kg/m^2	288	53.0
Obesity, prepregnancy BMI ≥ 30 kg/m^2	221	56.7

GWG: gestational weight gain; BMI: body mass index.

health-care-related factors, we found that women with two or more previous pregnancies showed a lower GWG than primipara women ($p < .05$). Among the sociodemographic factors, we found that women with lower education and those who lived alone tended to have higher GWG, but these results were not statistically significant (Table 3). Women who had fewer than six midwife visits had lower GWG than those who had more visits ($p < .05$).

We show the results from our crude and adjusted multinomial logistic regression models in Table 4. We considered women with a GWG within IOM recommendations as the reference group. We found that the statistically significant predictors of having a GWG below IOM recommendations were factors such as age less than 20 years, which was directly associated (RRR = 1.50, 95%

Table 3. Predictors of gestational weight gain.

Variable	Crude beta-coefficient (95% ci)	Adjusted beta-coefficient (95% ci)
Age < 20 years	1.94 (1.14, 2.73)**	0.70 (−0.25, 1.65)
Education < 12 years	0.38 (−0.29, 1.05)	0.30 (−0.43, 1.02)
Civil status single/divorced/widow	1.08 (0.45, 1.71)**	0.39 (−0.27, 1.06)
County of residence Puente Alto	−0.15 (−0.90, 0.60)	−0.06 (−0.99, 0.88)
Low socioeconomic status of PHCC	0.20 (−0.43, 0.84)	0.15 (−0.59, 0.89)
Prepregnancy BMI, kg/m^2		
Underweight, < 18.5	−0.28 (−2.44, 1.87)	−0.50 (−2.70, 1.70)
Normal weight, 18.5–25	Ref	Ref
Overweight, 25–30	−1.55 (−2.28, −0.82)**	−1.29 (−2.04, −0.53)**
Obesity, ≥ 30	−3.48(−4.29, −2.67)**	−3.10 (−3.95, −2.26)**
Height ≥ 158 cm	1.04 (0.40, 1.68)**	0.87 (0.24, 1.50)**
Parity (number of children)		
0 (primigesta)	Ref	Ref
1	−0.67 (−1.44, 0.93)*	−0.34 (−1.15, 0.47)
2 or more	−1.77 (−2.59, −0.94)**	−0.13 (−2.04, −0.21)**
Midwife prenatal visits, < 6	−1.03 (−1.66, −0.40)**	−0.94 (−1.62, −0.26)**
No referral to dietitian	−0.29 (−1.10, 0.51)	−0.64 (−1.59, 0.21)

Crude and adjusted linear regression models.
*$p < .10$; **$p < .05$.

Table 4. Predictors of gestational weight gain below and above of IOM recommendations. Crude and adjusted multinomial regression models.

	Below IOM recommendations		Above IOM recommendations	
Variable	Crude RRR (95% CI)	Adjusted RRR (95% CI)	Crude RRR (95% CI)	Adjusted RRR (95% CI)
Age < 20 years	1.39 (0.99, 1.95)*	1.50 (1.00, 2.25)*	1.54 (1.14, 2.08)**	1.63 (1.13, 2.37)**
Education < 12 years	1.07 (0.81, 1.41)	0.91 (0.67, 1.25)	1.41 (1.11, 1.80)**	1.28 (0.97, 1.69)
Civil status single/divorced/widow	1.04 (0.80,1.35)	1.00 (0.75, 1.32)	1.21 (0.96, 1.53)*	1.19 (0.92, 1.53)
County of residence Puente Alto	1.08 (0.80, 1.46)	1.07 (0.72, 1.59)	1.08 (0.83, 1.42)	1.17 (0.82, 1.68)
Low socioeconomic status of PHCC	0.95 (0.73, 1.23)	0.91 (0.67, 1.24)	1.09 (0.87, 1.37)	0.93 (0.70, 1.23)
Prepregnancy BMI, kg/m^2				
Underweight, < 18.5	1.92 (0.87, 4.25)	1.98 (0.85, 4.61)	0.96 (0.37, 2.48)	0.88 (0.33, 2.37)
Normal weight, 18.5–24.9	Ref	Ref	Ref	Ref
Overweight, 25–29.9	0.65 (0.47, 0.88)**	0.65 (0.47, 0.90)**	2.08 (1.58, 2.72)**	2.31 (1.73, 3.09)**
Obesity, ≥ 30	0.83 (0.59, 1.18)	0.86 (0.59, 1.24)**	2.41 (1.78, 3.26)**	2.90 (2.08, 4.03)**
Height ≥ 158 cm	0.99 (0.77, 1.29)	1.01 (0.77, 1.32)	1.33 (1.06, 1.68)**	1.43 (1.12, 1.82)**
Parity (number of children)				
0 (primigesta)	1.0	1.0	1.0	1.0
1	1.08 (0.85, 1.36)	1.20 (0.85, 1.69)	0.94 (0.74, 1.19)	1.01 (0.74, 1.37)
2 or more	1.07 (0.65, 1.74)	1.59 (1.09, 2.33)**	1.11 (0.69, 1.80)	0.96 (0.67, 1.36)
Midwife prenatal visits, < 6	1.27 (0.98, 1.65)*	1.36 (1.01, 1.82)**	0.78 (0.62, 0.99)**	0.78 (0.61, 1.02)*
No referral to dietitian	1.06 (0.75, 1.50)	0.97 (0.66, 1.42)	0.71 (0.53, 0.95)**	0.88 (0.63, 1.21)

Models are adjusted by gestational age at delivery.
*$p < .10$; **$p < .05$.

CI [1.00, 2.25]), and excess prepregnancy weight (overweight and obesity), which was inversely associated (overweight: RRR = 0.65, 95% CI [0.47, 0.90] and obesity: RRR = 0.86, 95% CI [0.59, 1.24]). Conversely, we observed that excess prepregnancy weight (overweight and obesity) was directly associated with having GWG above IOM recommendations (overweight: RRR = 2.31, 95% CI [1.73, 3.09] and obesity: RRR = 2.90, 95% CI [2.08, 4.03]). We also found that women who had height greater than 158 cm were also positively correlated with GWG above IOM recommendations (RRR = 2.31, 95% CI [1.73, 3.09]). Finally, women who had less than six midwife visits during pregnancy had a higher risk of having a GWG below IOM recommendations and a lower risk of being above IOM recommendations.

For sensitivity analysis to remove the effect of prepregnancy BMI on the dependent variable, we ran three multinomial regression models, one for each prepregnancy BMI and found similar results, which verified the results obtained from the general model (data not shown).

Discussion

In this prospective cohort of pregnant women from a Latin American country with a rapid nutrition transition, we found that almost 60% of women were overweight/obese before pregnancy and gained 13 kg on average during pregnancy. Additionally, we observed that only 32% of women experienced GWG within the range recommended by the IOM in 2009 (Institute of Medicine & National Research Council, 2009). While 24% of women had weight gain below the IOM recommendation, almost half of the women had weight gain above the IOM guidelines. These numbers are similar to those reported for other Latin populations (Chasan-Taber et al., 2008; Fraga & Theme Filha, 2014). For example, a study in Brazil showed that 20% and 50% of women gained below and above the IOM recommendations for GWG, respectively. Similarly, among Hispanic women in the United States, a study showed that 22% and 45% of women were below and above IOM recommendations, respectively (Chasan-Taber et al., 2008; Fraga & Theme Filha, 2014). On the other hand, Koleilat et al. showed a lower percentage of GWG below IOM recommendations in Hispanic women in the United States compared to the percentage we obtained in our study (Koleilat & Whaley, 2013). In the context of the global obesity epidemic, we think that it is worrisome that approximately 50% of the women in our cohort experienced GWG above IOM recommendations, consistent with other results reported in the literature in culturally diverse populations (Johnson et al., 2015).

Several authors have documented that GWG above IOM recommendations has short- and long-term implications for the mother as well as the baby (Norman & Reynolds, 2011; Poston, 2012). For example, this can lead to postpartum weight retention, aggravating the current obesity epidemic, with negative consequences for women's health and future pregnancies (Amorim, Rossner, Neovius, Lourenco, & Linne, 2007; Ma et al., 2015). Therefore, we believe that it would be recommendable for health care providers to provide counseling regarding diet and physical activity during pregnancy to help women achieve adequate weight gain and lose extra postpartum weight.

We identified several factors that are independently associated with higher GWG and noncompliance with IOM recommendations. First, women who were overweight and obese before pregnancy gained 1 and 3 kg less than normal women, respectively. This result is consistent with the results of other researchers who have shown that GWG is inversely associated with maternal prepregnancy BMI (Institute of Medicine & National Research Council, 2009). In 53,988 pregnant American women, Chu et al. showed that GWG was lower among obese women (Chu, Callaghan, Bish, & D'Angelo, 2009). In an analysis of single pregnancies in Germany, Voight et al. also showed this inverse relationship between BMI and GWG (Voigt, Straube, Schmidt, Pildner von Steinburg, & Schneider, 2007). We think that this could be explained by the fact that the energy status of women prior to conception influences their metabolic responses during pregnancy and, therefore, the energy expenditure associated with it. The higher the maternal weight, the smaller the weight gain, which would explain why the weight gain in obese pregnant women is lower (Melzer & Schutz, 2010).

On the other hand, we found that excess prepregnancy weight (overweight and obesity) was the strongest positively associated predictor for GWG above IOM recommendations; we believe that this result is most likely due to the more restrictive GWG recommendations for the overweight and obese categories compared to those for normal prepregnancy weight. Our findings are consistent with those of previous studies in other populations (Chasan-Taber et al., 2008; Samura et al., 2016).

Our study also found that maternal age was positively correlated with higher GWG; adolescent pregnant women (<20 years old) gained 2 kg more weight on average than older women. When considering GWG as being compliant or not to IOM recommendations, adolescents have one and a half times the risk of being below IOM recommendations and of having GWG above recommendations. A possible explanation for this behavior could be that IOM recommendations are tailored for adult populations and might not consider specific nutritional requirements for adolescents according their developmental stage (Institute of Medicine & National Research Council, 2009). Therefore, it would be desirable to explore specific GWG recommendations designed for adolescents.

We also observed that the primiparae gained more weight compared to multiparas even after further adjustment by age and prepregnancy BMI. One possible hypothesis for this finding is that multiparae, in general, plan their pregnancies ahead of time and are concerned about weight because of previous experience.

In relation to education, we did not find a significant difference among women with different levels of literacy. Although other studies have found that less educated women are at greater risk of being above GWG recommendations compared to educated women (Campbell et al., 2016; Koleilat & Whaley, 2013) due to the lack of access to a healthier diet and physical activity, we did not have a definitive conclusion. One possible explanation is the homogeneous nature of the women in our database regarding education.

We also found that taller women had higher GWG on average, and a higher percentage of these women had GWG above IOM recommendations, compared to shorter pregnant women. However, given that IOM recommendations consider a GWG range according to the initial BMI, this implies that taller women would gain weight closer to the upper limit of this range, and therefore, it is easier to surpass this limit. In relation to health care factors, we found that women with fewer midwife visits had a higher risk of being below GWG recommendations but a lower risk of being above recommendations. A plausible reason for this could be that women who experience rapid GWG or any pregnancy-related complication are monitored more often. However, we think that could be an opportunity to offer counseling to women to avoid having a GWG above recommendations.

We understand that our study has limitations. First, we did not have information regarding the women's life style such as diet, physical activity or smoking habits, which have been shown to be predictors of GWG in other studies (Heery, Kelleher, Wall, & McAuliffe, 2015; Restall et al., 2014). Additionally, the recorded pregestational weights in our study were self-reported, which could lead to bias; however, there is evidence that self-reported and actual weights have good correlation (Kuczmarski, Kuczmarski, & Najjar, 2001; Tomeo et al., 1999). We think that one important strength of our study is the fact that this was a longitudinal study in a cohort of women of low and medium socioeconomic levels and that the maternal weights at midwife visits and at delivery were measured and obtained in a prospective manner.

We conclude that strategies for achieving adequate GWG are highly dependent on the identification of modifiable risk factors. We believe that women who are overweight/obese at the beginning of pregnancy should be identified because of their higher risk and that adequate strategies should be designed and implemented to help them achieve a healthy GWG. Additionally, prevention of pregestational obesity through personalized and public policies is important to avoid further complications for the mother and offspring during and after pregnancy.

We think that an important insight obtained from our study is that women with GWG above the IOM recommendations had more midwife visits throughout their pregnancies. We believe that this finding indicated an excellent opportunity for the health care system to offer counseling (diet, physical, or other) to women in order to avoid excess weight gain and further complications in future pregnancies.

Acknowledgments

The Ministry of Health of Chile, the South East Health Service and the La Florida and Puente Alto counties have provided in kind support for the implementation of the study. The authors thank all the participants in this study for generously helping them in this research.

Funding

The Chilean Maternal and Infant Nutrition Cohort study (CHiMINCs, trial registration NCT01916603) was funded by the Chilean National Fund for Scientific and Technological Development, FONDECYT# 1130277. O Matus is funded by *Ingenieria 2030* ("Fes-UAI Strategic Plan Implementation, New Engineering 2030" 14ENI2-26865), Universidad Adolfo Ibañez.

References

Amorim, A. R., Rossner, S., Neovius, M., Lourenco, P. M., & Linne, Y. (2007). Does excess pregnancy weight gain constitute a major risk for increasing long-term BMI? *Obesity (Silver Spring)*, *15*(5), 1278–1286. doi:10.1038/oby.2007.149

Araya, B. M., Padilla, O., Garmendia, M. L., Atalah, E., & Uauy, R. (2014). Prevalence of obesity among Chilean women in childbearing ages. *Revista Medica de Chile*, *142*(11), 1440–1448. doi:10.4067/S0034-98872014001100011

Atalah, E., Castillo, C., Castro, R., & Aldea, A. (1997). Propuesta de un nuevo estándar de evaluación nutricional en embarazadas. *Revista Medica de Chile*, *125*, 1429–1436.

Atalah, E., & Castro, R. (2004). Maternal obesity and reproductive risk. *Revista Medica de Chile*, *132*(8), 923–930.

Campbell, E. E., Dworatzek, P. D., Penava, D., de Vrijer, B., Gilliland, J., Matthews, J. I., & Seabrook, J. A. (2016). Factors that influence excessive gestational weight gain: Moving beyond assessment and counselling. *The Journal of Maternal-Fetal Neonatal Medicine*, *29*(21), 3527–3531. doi:10.3109/14767058.2015.1137894

Chasan-Taber, L., Schmidt, M. D., Pekow, P., Sternfeld, B., Solomon, C. G., & Markenson, G. (2008). Predictors of excessive and inadequate gestational weight gain in Hispanic women. *Obesity (Silver Spring)*, *16*(7), 1657–1666. doi:10.1038/oby.2008.256

Chu, S. Y., Callaghan, W. M., Bish, C. L., & D'Angelo, D. (2009). Gestational weight gain by body mass index among US women delivering live births, 2004-2005: Fueling future obesity. *American Journal of Obstetrics and Gynecology*, *200*(3), 271.e271–277. doi:10.1016/j.ajog.2008.09.879

Fraga, A. C., & Theme Filha, M. M. (2014). Factors associated with gestational weight gain in pregnant women in Rio de Janeiro, Brazil, 2008. *Cademos de Saúde Pública*, *30*(3), 633–644.

Garmendia, M. L., Corvalan, C., Araya, M., Casanello, P., Kusanovic, J. P., & Uauy, R. (2015). Effectiveness of a normative nutrition intervention (diet, physical activity and breastfeeding) on maternal nutrition and offspring growth: The Chilean maternal and infant nutrition cohort study (CHiMINCs). *BMC Pregnancy Childbirth*, *15*, 175. doi:10.1186/s12884-015-0605-1

Government of Chile, Ministry of Health. (2015). *Vigilancia del estado nutricional de la poblacion bajo control y de la lactancia materna en el Sistema Público de Chile* [Surveillance of the nutritional status of the population under control and of breastfeeding in the public system of Chile]. Santiago, Chile: Author. Retrieved from http://web.minsal.cl/sites/default/files/files/Informe%20Vigilancia%20Nutricional%20y%20Lactancia%20Materna%20Diciembre%202014.docx.pdf

Heery, E., Kelleher, C. C., Wall, P. G., & McAuliffe, F. M. (2015). Prediction of gestational weight gain—A biopsychosocial model. *Public Health Nutrition*, *18*(8), 1488–1498. doi:10.1017/S1368980014001815

Hosmer, D., & Lemeshow, S. (2000). *Applied logistic regression* (2nd ed.). New York, NY: John Wiley & Sons, Inc.

Institute for Digital Research and Education UCLA. (2017). *Stata data analysis examples—Multinomial logistic Regression*. Retrieved from http://www.ats.ucla.edu/stat/stata/dae/mlogit.htm

Institute of Medicine, & National Research Council. (2009). *Weight gain during pregnancy: Reexamining the guidelines*. Washington, DC: Author.

Johnson, J. L., Farr, S. L., Dietz, P. M., Sharma, A. J., Barfield, W. D., & Robbins, C. L. (2015). Trends in gestational weight gain: The pregnancy risk assessment monitoring system, 2000–2009. *American Journal of Obstetrics and Gynecology*, *212*(6), 806.e801–808. doi:10.1016/j.ajog.2015.01.030

Koleilat, M., & Whaley, S. E. (2013). Trends and predictors of excessive gestational weight gain among hispanic WIC participants in Southern California. *Maternal and Child Health Journal*, *17*(8), 1399–1404. doi:10.1007/s10995-012-1140-6

Kuczmarski, M. F., Kuczmarski, R. J., & Najjar, M. (2001). Effects of age on validity of self-reported height, weight, and body mass index: Findings from the third national health and nutrition examination survey, 1988–1994. *Journal of the American Dietetic Association*, *101*(1), 28–34; quiz 35–26. doi:10.1016/S0002-8223(01)00008-6

Leddy, M. A., Power, M. L., & Schulkin, J. (2008). The impact of maternal obesity on maternal and fetal health. *Reviews in Obstetrics and Gynecology*, *1*(4), 170–178.

Long, J., & Freese, J. (2006). *Regression models for categorical and limited dependent variables using stata*, Second Edition. College Station, TX: Stata Press.

Ma, D., Szeto, I. M., Yu, K., Ning, Y., Li, W., Wang, J., & Wang, P. (2015). Association between gestational weight gain according to prepregnancy body mass index and short postpartum weight retention in postpartum women. *Clinical Nutrition*, *34*(2), 291–295. doi:10.1016/j.clnu.2014.04.010

Melzer, K., & Schutz, Y. (2010). Pre-pregnancy and pregnancy predictors of obesity. *International Journal of Obesity (London)*, *34*(Suppl. 2), S44–52. https://doi.org/ijo2010239 [pii] 10.1038/ijo.2010.239

Nelson, S. M., Matthews, P., & Poston, L. (2009). Maternal metabolism and obesity: Modifiable determinants of pregnancy outcome. *Human Reproduction Update*, *16*(3), 255–275. doi:10.1093/humupd/dmp050

Norman, J. E., & Reynolds, R. M. (2011). The consequences of obesity and excess weight gain in pregnancy. *Proceedings of the Nutrition Society*, *70*(4), 450–456. doi:10.1017/S0029665111003077

O'Reilly, J. R., & Reynolds, R. M. (2013). The risk of maternal obesity to the long-term health of the offspring. *Clinical Endocrinology (Oxford)*, *78*(1), 9–16. doi:10.1111/cen.12055

Organisation for Economic Co-operation and Development (OECD). (2010). *Chilés accesión to the OECD*. Retrieved from http://www.oecd.org/chile/chilesaccessiontotheoecd.htm

Organisation for Economic Co-operation and Development (OECD). (2015). *In it together. Why less inequality benefits all*. Paris, France: Author. doi:10.1787/9789264235120-en

Poston, L. (2012). Gestational weight gain: Influences on the long-term health of the child. *Current Opinion in Clinical Nutrition and Metabolic Care*, *15*(3), 252–257. doi:10.1097/MCO.0b013e3283527cf2

Restall, A., Taylor, R. S., Thompson, J. M., Flower, D., Dekker, G. A., Kenny, L. C., & McCowan, L. M. (2014). Risk factors for excessive gestational weight gain in a healthy, nulliparous cohort. *Journal of Obesity*, *2014*, 148391. doi:10.1155/2014/148391

Samura, T., Steer, J., Michelis, L. D., Carroll, L., Holland, E., & Perkins, R. (2016). Factors associated with excessive gestational weight gain: Review of current literature. *Global Advances in Health and Medicine*, *5*(1), 87–93. doi:10.7453/gahmj.2015.094

Tomeo, C. A., Rich-Edwards, J. W., Michels, K. B., Berkey, C. S., Hunter, D. J., Frazier, A. L., & Buka, S. L. (1999). Reproducibility and validity of maternal recall of pregnancy-related events. *Epidemiology*, *10*(6), 774–777.

Voigt, M., Straube, S., Schmidt, P., Pildner von Steinburg, S., & Schneider, K. T. (2007). Standard values for the weight gain in pregnancy according to maternal height and weight. *Zeitschrift fur Geburtshilfe und Neonatologie*, *211*(5), 191–203. doi:10.1055/s-2007-981327