Gestational weight gain in a multi-ethnic sample of pregnant women from Counties Manukau Health, Auckland, New Zealand

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ABSTRACT

AIM: High and low gestational weight gain (GWG) adversely affects perinatal outcomes, and impacts long-term maternal and child health. Our aim is to report i) GWG categories by 2009 Institute of Medicine guidelines in the multi-ethnic population in Counties Manukau Health, ii) demographic factors and iii) adverse perinatal outcomes associated with high and low GWG.

METHOD: Women with singleton pregnancy and weight recorded at ≤20 weeks and again in the third trimester comprised the study population. GWG categories (weight gain per week) were defined as low, normal or high. Maternal characteristics and pregnancy outcomes were compared between GWG categories.

RESULTS: Study population comprised 604 women: 39.7% Pacific, 19.9% Māori, 21.5% European. 70.5% were overweight or obese, and 65.1% lived in the highest deprivation decile areas. 70.7% had high, 16.1% had normal and 13.2% had low GWG. Pacific [OR 3.58 (95% CI 1.82, 7.03)] had increased odds of high GWG and Para 2/3$^+$ had reduced odds of high GWG [OR 0.50 (95% CI 0.26, 0.99), OR 0.36 (95% CI 0.17, 0.74) respectively]. Low GWG was associated with increased SGA [OR 2.48 (95% CI 1.11, 6.44)] and with GDM [OR 2.74 (95%CI 1.06, 8.79)]. We demonstrated a linear association between GWG and birthweight with 126g (95% CI: 90g, 162g) increase per 250g increase in weekly GWG.

CONCLUSION: The majority of participants had high GWG, which is clinically relevant as this was associated with increased infant weight, with potential to perpetuate intergenerational obesity. The association between low GWG and GDM may reflect care in the GDM clinic.

High gestational weight gain (GWG) is associated with adverse pregnancy outcomes, including caesarean section, large for gestational age infants (LGA), gestational hypertension and gestational diabetes (GDM). International studies, performed predominantly in European and Asian women, report that one- to two-thirds gain excessive weight in pregnancy.[1–6] Long-term adverse outcomes associated with high GWG include obesity for the offspring and weight retention for the mother, perpetuating the inter-generational obesity cycle.[5,6] Low GWG, though less common, has been associated with pregnancy complications of spontaneous preterm birth and small for gestational age infants (SGA).[3,5]

Obesity during pregnancy has similar risks to high GWG, but abnormal GWG is an independent risk factor for pregnancy complications after adjusting for body mass index (BMI).[3,7–11] While obesity cannot be reversed during pregnancy, GWG is a modifiable risk factor. Importantly, dietary interventions can reduce pregnancy weight gain and improve pregnancy outcomes.[6,12]

There is only one previous study on pregnancy weight gain that included New Zealand women (SCOPE study).[13] In this analysis from the SCOPE study, comprising healthy predominantly European nulliparous women, 14% of participants were from Auckland. In this study, 74% of participants had high, 17% had normal and 9% had low GWG. These results may not be generalisable to the multi-ethnic Counties Manukau setting.

The Counties Manukau Health (CMH) area in South Auckland, New Zealand serves a multi-ethnic community, where 52.4% of the maternity population lives in the most deprived deciles compared to 20% for the rest of New Zealand.[14,15] This community has very high rates of obesity with 41% of all women entering pregnancy with obesity (50% of Māori, 70% of Pacific, 26% of European and 7% of Asian/other)[14] and high rates of adverse pregnancy outcomes including stillbirth.[16] While an association has been found between high obesity rates and adverse outcomes in this community, there are no data on GWG. Such data are necessary to establish a baseline and to plan suitable interventions.

We aimed to: i) identify the proportion of women within CMH who gain weight within and outside the 2009 Institute of Medicine (IOM) Guideline ranges,[7] ii) assess demographic factors associated with GWG categories, and iii) assess adverse maternal and neonatal outcomes associated with low and high GWG.

Methods

Ethics

The Health and Disability Ethics (HDEC) NZ Online Form (nz.ethicsform.org) was completed to assess the need for full ethical review. The current study met the HDEC definition for observational research[17] and therefore did not require HDEC ethical review. Locality approval was obtained to conduct the study in Counties Manukau Health.

Study design and participants

This was a prospective observational study using data from consecutive women, booked for birth with CMH employed midwives from September 2014 to March 2016. The inclusion criteria were; a singleton pregnancy, first visit gestation ≤20 weeks confirmed by ultrasound, maternal weight recorded in hospital database at ≤20 weeks and in the third trimester. Exclusion criteria were multiple pregnancy, serious maternal medical conditions (type 1 or 2 diabetes, essential hypertension, anti-phospholipid syndrome, systemic lupus erythematosis, chronic renal disease). Data were extracted from the hospital database. Participants received antenatal care from their lead maternity care provider.

Weight and height measurements

All CMH midwifery clinics were provided with identical weighing scales (SECA 813) and stadiometers (SECA 206) to ensure standardisation during data collection. All weighing scales were calibrated by CMH clinical engineers before and during the study period. All CMH midwives were informed of the study and the use of the equipment. Women were weighed in light clothing without shoes at every antenatal clinic visit as per CMH guidelines. Height was measured in centimetres (to one decimal point) using the stadiometer with no shoes, head upright and heels flat against the wall at first visit. Weight was measured in kilograms and rounded to one decimal point. Gestation at each weight measurement was calculated based on estimated date of delivery according to dating ultrasound scan performed at ≤20 weeks' gestation.

Determining BMI and GWG

BMI was defined as weight in kg (in early pregnancy) by height at first visit in meters squared. GWG was defined as kg/week through the second and third trimesters. The 2009 IOM reference ranges for optimal GWG for maternal BMI group was used (underweight 0.44–0.58kg/week, normal weight 0.35–0.50kg/week, overweight 0.23–0.33kg/week and obese 0.17–0.27kg/week).[7] Using these ranges and the BMI category, we classified women as having low, normal or high GWG.[7]

As this was an observational study, large variation occurred in gestational age when first and later weights were measured and in the number of weight measurements. Statistical modelling was therefore used to adjust for the variation in the timing and number of the weight recordings. See specific details in statistical analysis.

Demographic characteristics and secondary maternal and infant outcomes

At the first antenatal visit demographic data were entered by the midwife into the hospital database including: age, home suburb (to generate New Zealand deprivation index—NZDep2013), parity, ethnicity, smoking status and estimated date of delivery[18] by ultrasound scan (≤20 weeks' dating scan).

Information about secondary maternal and neonatal outcomes were extracted from the hospital database. These included: gestational hypertension, pre-eclampsia, GDM, gestation at delivery, mode of delivery, infant birthweight, sex and birthweight centiles. Gestational hypertension was defined as systolic BP ≥140 or diastolic BP ≥90mmHg on at least two occasions six hours apart after 20 weeks' gestation but before onset of labour;[19] and pre-eclampsia as systolic BP ≥140 or diastolic BP ≥90mmHg on at least two occasions six hours apart (after 20 weeks but before labour) plus proteinuria defined as Protein Creatinine Ratio ≥30mg/mmol or other organ dysfunction.[19] GDM was defined as: fasting blood glucose ≥5.5mmol/L or two-hour ≥9.0mmol/L on 75g oral glucose tolerance test (OGTT) or if no OGTT as polycose ≥11.1mmol/L.[20] Customised birthweight centiles were calculated using maternal height, early pregnancy weight, parity, ethnicity as well as infant sex, birthweight and gestation at delivery using the New Zealand bulk calculator.[21] Large for gestational age was defined as birthweight >90th customised centile,[22] and small for gestational age as birthweight <10th customised centile.[22]

Statistical analysis

The sample size was calculated based on the reported counts of births in Counties Manukau by BMI category and ethnicity in 2012[14,16] to achieve an expected precision of the estimated proportion in each BMI category (normal, overweight and obese) while maintaining the expected overall distribution of main ethnic groups in the Counties Manukau population. Consecutive recruitment continued until the minimum required sample size for each ethnic group was met.

Statistical modelling for early-pregnancy weight and GWG was done using linear mixed models with individual women as random effects. This allowed modelling of how each woman gained weight across the pregnancy using all obtained weights in segments of linear weight gain (called spline models). We tested various spline models investigating different gestation points (knots) where women started gaining weight (gestation tested: 13–18 weeks) and if the weight gain rate changed in late gestation (gestation tested: 34–39 weeks). A model with knots at week 15 and 34 fitted the data best. This model identified that no significant weight gain occurred prior to 15 weeks, a linear weight gain was present between 15 and 34 weeks and a non-significant decrease in weekly weight gain occurred after 34 weeks. Using the best linear unbiased predictions (BLUPs, individualised estimates from the overall model for each individual's observations and trends) we obtained early pregnancy weight and GWG for each woman. Proportions of low and high GWG were estimated with 95% family-wide confidence intervals using Wilson's method.[23]

Multi-way multinomial logistic regression (baseline-category logit model) was used to assess which demographic factors (stepwise analysis, removal rule p-value>0.1 and addition rule p-value<0.1), including gender of infant, were associated with GWG categories. One-way analysis (Chi-squared test of independence or Fisher's exact in case of assumptions not met) was used to assess individual associations between GWG categories and maternal and neonatal outcomes. For those with a significant association (p-value <0.05) 'small sample size adjusted' odds ratios were calculated with normal weekly GWG as baseline and 95% family-wide confidence intervals. ANCOVA was used to assess if the non-categorical weekly GWG was associated with birthweight when age, BMI, smoking status, ethnicity, gender of infant, parity, deprivation status, gestation at delivery, gestational hypertension and GDM were considered. All assumptions were checked at every step in the statistical models.

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Results

The study population comprised of 604 women, age ranging from 14 to 47 years.

Women of Pacific and Māori ethnicity made up 59.6% of the population (39.7% and 19.9% respectively). Multiparous women made up 66.4% of the population and 65.1 % of the population lived in the highest deprivation deciles 9 and 10. Demographics characteristics, maternal and neonatal outcomes are described in Table 1.

Table 1: Demographic characteristics and pregnancy outcomes for each IOM weekly gestational weight gain category.

Variable	N=604	Institute of Medicine (IOM) Guidelines Weight Category		
		Low (n=80)	Normal (n=97)	High (n=427)
Age (y)	28.4 (6.5)	29.0 (6.9)	29.3 (5.9)	28 (23, 33)
Height (m)	1.65 (0.07)	1.62 (1.59, 1.68)	1.63 (1.58, 169)	1.66 (0.06)
Early pregnancy weight (kg)	80.2 (64.4, 98.8)	81.8 (67.4, 109.9)	66.4 (56.0, 86.9)	82.8 (66.7, 99.7)
BMI (kg/m²)	29.6 (24.2, 35.6)	30.2 (24.6, 38.3)	24.6 (22.1, 32.3)	30.1 (25.1, 35.8)
Ethnicity				
European	130 (21.5%)	14 (17.5%)	25 (25.8%)	91 (21.3%)
Asian	52 (8.6%)	6 (7.5%)	16 (16.5%)	30 (7.0%)
Indian	62 (10.3%)	8 (10.0%)	21 (21.6%)	33 (7.7%)
Māori	120 (19.9%)	26 (32.5%)	17 (17.5%)	77 (18.0%)
Pacific	240 (39.7%)	26 (32.5%)	18 (18.6%)	196 (45.9%)
Smokers	112 (18.8%) (n=596)	20 (25.3%)	17 (17.9%)	75 (17.8%)
Parity				
0	203 (33.6%)	15 (18.8%)	29 (29.9%)	159 (37.2%)
1	180 (29.8%)	26 (32.5%)	30 (30.9%)	124 (29.0%)
2	107 (17.7%)	12 (15.0%)	20 (20.6%)	75 (17.6%)
3+	114 (18.9%)	27 (33.8%)	18 (18.5%)	69 (16.2%)
Gestation at birth	39.3 (38.4, 40.1)	39.1 (38.3, 39.9)	39.1 (38.1, 39.9)	39.3 (38.6, 40.3)
Deprivation decile				
1–2	41 (6.8%)	5 (6.3%)	10 (10.3%)	26 (6.1%)
3–4	44 (7.3%)	2 (2.5%)	11 (11.3%)	31(7.3%)
5–6	0 (6.6%)	8 (10.0%)	6 (6.2%)	26 (6.1%)
7–8	86 (14.2%)	13 (16.3%)	21 (21.6%)	52 (12.3%)
9–10	393 (65.1%)	52 (65.0%)	49 (50.5%)	292 (68.4%)
Gender—Female	272 (45.0%)	37 (46.3%)	39 (40.2%)	196 (45.9%)
Gestational hypertension	28 (4.6%)	1 (1.3%)	4 (4.1%)	23 (5.4%)
Gestational diabetes	58 (9.9%) (n=585)	16 (20.8%)	7 (7.6%)	35 (8.4%)
Mode of delivery				
Vaginal	427 (70.7%)	62 (77.5%)	70 (72.2%)	295 (69.1%)
Elective caesarean	73 (12.1%)	11 (13.8%)	15 (15.5%)	47 (11.0%)
Emergency caesarean	104 (17.2%)	7 (8.8%)	12 (12.4%)	85 (19.9%)
Birthweight (g)	3,453 (558)	3,256 (477.3)	3,340 (2,950, 3,680)	3,527 (550.4)

Continuous data are mean (SD), median (25^{th}–75^{th} IQR) as appropriate.
Categorical data are count (%).

Table 2: Multinomial regression analysis of demographics associated with Institute of Medicine (IOM) Guidelines for Gestational Weight Gain (GWG) Category.

Variable	Level	Odds ratios (95% CI): normal GWG as referent	
		Low GWG	High GWG
Ethnicity	European	Referent	Referent
	Asian	0.66 (0.21; 2.08)	0.48 (0.22; 1.03)
	Indian	0.71 (0.25; 2.06)	0.37 (0.18; 0.76)*
	Māori	2.61 (1.05; 6.46)*	1.4 (0.69; 2.82)
	Pacific	2.43 (0.98; 6.02)	3.58 (1.82; 7.03)*
Parity	0	Referent	Referent
	1	1.72 (0.75; 3.95)	0.76 (0.42; 1.37)
	2	0.96 (0.36; 2.53)	0.50 (0.26; 0.99)*
	+3	1.77 (0.71; 4.45)	0.36 (0.17;0.74)*

Odds ratios (95%CI) are from a model which includes ethnicity and parity as explanatory variables.
*Confidence interval does not include 1.00.

Of the 604 women, 529 (87.6%) had weights recorded four times in the pregnancy, 47 (7.8%) had three and 28 (4.6%) had two weights recorded. First weight was recorded between 6.3 and 20.0 weeks of gestation (median 14.7 weeks) and the last weight was measured between 26.0 and 41.7 weeks of gestation (median 37.6). After modelling, the estimated early pregnancy BMI ranged from 14.8 to 55.3 (median 29.6) with 18 (3.0 %) participants being underweight, 160 (26.5%) normal weight, 135 (22.4%) overweight and 291 (48.2%) obese.

The estimated mean weekly GWG between 15 and 34 weeks' gestation was 0.51kg per week (95% confidence interval: 0.49, 0.53kg/week. According to the IOM GWG categories 13.2% (95% CI: 10.5, 16.6%) had low, 16.1% (95%CI: 13.3, 19.2%) had normal and 70.7% (95% CI: 66.4, 74.7%) had high GWG.

The multi-way multinomial regression analysis of demographic characteristics showed that only ethnicity (p<0.0001) and parity (p=0.0003) remained significantly associated with GWG categories. Māori women had higher odds of low GWG [OR 2.61, (95% CI: 1.05, 6.46)], Pacific women had increased odds of high GWG [OR 3.58, (95% CI: 1.82, 7.03)] and Indian women lower odds of high GWG [OR 0.37, (95% CI 0.18, 0.76)] than European. While women with one previous child did not differ from nulliparous women, those with two or more previous children had reduced odds for high GWG compared with nulliparous women (see Table 2). After adjustment for ethnicity and parity, age, smoking status, gender of the infant, deprivation category and BMI were no longer associated with GWG categories (p-values >0.10).

In the one-way analyses low GWG was associated with gestational diabetes (p-value=0.0028) and SGA infants (p-value 0.0007), (see Table 3). The effect of increased SGA in women with low GWG persisted in the sensitivity analysis after excluding GDM. The GWG categories were marginally associated with mode of delivery (p-value 0.0700) and early gestation at delivery <37/40 (p-value 0.0515).

In ANCOVA analysis, non-categorised weekly GWG remained associated (p<0.0001) with birthweight when adjusted for maternal age, BMI, smoking status, ethnicity, infant sex, parity, deprivation status, gestation at delivery, gestational hypertension and GDM. The birthweight increased by 126g (95% CI: 90–162) for each 250g increase in weekly GWG.

Discussion

This is the first study to report GWG in a multi-ethnic population comprising of a large proportion of Māori and Pacific women with high rates of overweight and obesity in early pregnancy. The majority of participants (70.7%) had high weekly GWG, similar to the 74.3% reported in the previous study of predominantly white New Zealand nulliparous women.[13] Our rate of high GWG

Table 3: Results of one-way analysis looking at Institute of Medicine (IOM) Guidelines for Gestational Weight Gain (GWG) Categories association with pregnancy outcomes where p-value<0.05.

Variable	Level	IOM weekly GWG category			Odds ratio (95% CI)	
		Normal	Low	High	Low vs Normal	High vs Normal
Gestational diabetes	No	85	61	381	Referent	Referent
	Yes	7	16	35	2.74 (1.06; 8.79)*	0.97 (0.41; 2.72)
Size for gestational age	AGA	77	54	315	Referent	Referent
	SGA	12	23	55	2.48 (1.11; 6.44)*	1.03 (0.51; 2.33)
	LGA	8	3	57	0.47 (0.13; 2.57)	1.54 (0.70; 3.97)

Counts and small-sample size adjusted odds ratios with Bonferroni correction confidence interval to keep 95% confidence for each variable.
Normal GWG is referent group.
*Confidence interval does not include 1.00

is in-keeping with other studies showing that overweight and obese women have elevated risk of high GWG.[7,13,24] In our study 13.2% had low GWG, lower than the 23% reported in a recent systematic review where the included trials were conducted in the US, Europe and Asia.[3]

Consistent with previous reports,[25,26] we found ethnicity to be significantly associated with GWG. We found that when compared with European, Pacific women had higher odds of high GWG (OR 3.58 (95% CI 1.82, 7.03), Indian women had lower odds of high GWG (OR 0.37 (95%CI 0.18, 0.76) and Māori had higher odds of low GWG (OR 2.61 (95% CI 1.05, 6.46). The explanation for these findings requires further investigation but the elevated odds of high GWG in Pacific is important information for maternity care providers as high GWG is associated with short- and long-term health complications in women and their children.[1–6]

In our population; women who were para 2, 3 or more had reduced odds of high GWG compared with nulliparous women. A recent systematic review and meta-analysis, reported that the relationship between parity and GWG categories was inconsistent, with studies showing both positive and negative associations, suggesting that this relationship may vary by geographic location.[27]

Consistent with a recent systematic review,[3] we found increased odds for SGA infants [OR 2.48, (95%CI 1.06, 8.79)] in women with low GWG. Gaining an optimal amount of weight is a strategy with potential to reduce the prevalence of SGA. Consistent with findings from a Chinese study,[28] we found that low total GWG was associated with increased odds for GDM [OR 2.74 (95% CI 1.06, 8.79)]. We, and the Chinese authors, speculate that this association may reflect care in the GDM service where women are encouraged to limit weight gain after GDM diagnosis. Other publications have reported that high GWG in early pregnancy and prior to testing for GDM are associated with increased GDM.[2,29] We were not able to investigate the relationship with early GWG and GDM in our study.

We found a borderline association between mode of delivery (p-value 0.0700) and GWG categories. The increasing percentage of emergency caesarean section across GWG categories and decreasing percentage of vaginal births from low to high GWG categories, although not statistically significant in our study, is consistent with findings in the systematic review.[3]

Of concern, we also demonstrated a linear relationship between increasing GWG and increasing birthweight, which could contribute to the elevated risk of childhood obesity in the Counties Manukau community.[30] This finding is consistent with another study[31] that also reported that GWG had a linear association with birthweight, and the more frequently reported association of low GWG with SGA and high GWG with LGA infants.[3]

The strengths of this study include the prospective design allowing the use of standardised weighing scales and stadiometer to measure height and weight. The observational design allowed data from all women attending the clinic to be incorporated in the study, with the distribution of ethnicity and deprivation decile in our study being comparable to that for this area.[14] While the observational study design increased the variation in the number of weights measured and the gestation at measurement, we used statistical modelling to minimise any potential bias caused by this variation. The consistency of our findings with other studies suggests that bias is likely to have been minimised in our study.

The study provides the first data on GWG in Pacific and Māori women who are over-represented in adverse pregnancy outcome statistics in New Zealand. A limitation is that we were underpowered to investigate the relationship between GWG and less common adverse pregnancy outcomes.

Multiple studies of dietary and/or physical activity interventions have been undertaken to try to limit excessive gestational weight gain. Recent meta-analyses have shown modest reductions in gestational weight gain with dietary and/or physical activity interventions in pregnancy, however the large majority of participants in these meta-analyses were European.[6,12] The Healthy Mums and Babies (HUMBA) Study, a randomised trial of a culturally tailored dietary intervention provided by community health workers, was recently completed in the Counties Manukau DHB among a multi-ethnic population with obesity.[32] Pregnant women who received the dietary intervention had 1.8kg lower total GWG compared with those who received routine dietary advice. Ongoing follow-up will determine whether this modest reduction in pregnancy weight gain impacts on longer-term health in the mothers and babies.[33]

Conclusion

The majority of women in this multi-ethnic high deprivation sample gained an excessive amount of weight during pregnancy. Pregnancy weight gain was positively associated with birthweight and may contribute to the high rates of childhood obesity in this community. The demographic factors associated with abnormal GWG provide information about where resources aimed to optimise GWG could be directed.

Competing interests:

Nil.

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