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# Sociodemographic determinants of prepregnancy body mass index and gestational weight gain: The Mutaba'ah study

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## Abstract

**Objective:** This study examined the associations of sociodemographic and lifestyle factors with prepregnancy body mass index (BMI) and gestational weight gain (GWG).

**Methods:** In the Mutaba'ah Study in the United Arab Emirates, repeated measurements throughout pregnancy from medical records were used to determine prepregnancy BMI and GWG. Associations of sociodemographic and lifestyle factors with prepregnancy BMI and GWG (separately by normal weight, overweight, and obesity status) were tested using multivariable regression models, adjusted for maternal age at delivery.

**Results:** Among 3536 pregnant participants, more than half had prepregnancy overweight (33.2%) or obesity (26.9%), and nearly three-quarters had inadequate (34.2%) or excessive (38.2%) GWG. Higher parity ($\beta$ for 1–2 to ≥5 children = 0.94 to 1.73 kg/m$^2$), lower maternal education ($\beta$ for tertiary = −1.42), infertility treatment ($\beta$ = 0.69), and maternal prepregnancy active smoking ($\beta$ = 1.95) were independently associated with higher prepregnancy BMI. Higher parity was associated with a lower risk for excessive GWG among women with prepregnancy normal weight (odds ratios (ORs) for 1–2 to ≥5 children = 0.61 to 0.39). Higher maternal education was negatively associated with inadequate GWG among women with normal weight and overweight (ORs for tertiary education = 0.75 and 0.69, respectively).

**Conclusions:** Sociodemographic factors, especially parity and maternal education, were differentially associated with prepregnancy BMI and GWG adequacy across weight status.

KEYWORDS

gestational weight gain, maternal education, parity, prepregnancy body mass index, sociodemographics

Tuck Seng Cheng and Nasloon Ali are joint first authors.

## 1 | INTRODUCTION

Early-life exposures starting from preconception have been increasingly recognized to play an important role in short- and long-term health outcomes in both mothers and offspring, consistent with the Developmental Origins of Health and Disease hypothesis.[1] Prepregnancy body mass index (BMI) and gestational weight gain (GWG) represent important physical markers of a woman's overall living conditions and lifestyle behaviors throughout pregnancy. A large body of evidence has demonstrated that higher prepregnancy BMI and GWG above the Institute of Medicine (IOM) guidelines[2] are associated with higher risks for pregnancy complications including gestational hypertension, gestational diabetes mellitus, caesarean delivery, and large for gestational age at birth.[3-5] These associations remain similar across continents and ethnicities even when population-specific BMI categories were considered.[6] Moreover, preconception overweight and obesity is associated with poorer neurocognitive development[7] and childhood overweight and obesity in offspring.[8] These findings suggest that the need to develop interventions targeting prepregnancy BMI and GWG to reduce the burden of possible future health issues in both the mother and child.

Diverse factors have been associated with overweight and obesity, and excessive GWG, which include physiological, psychological, environmental, social, and behavioral exposures,[9,10] and notably, these factors usually vary by sociodemographic status.[11] It is possible that sociodemographic determinants may influence individual choices or preferences of exposures and behaviors, subsequently affecting prepregnancy BMI and GWG. A systematic review found that low maternal education, rather than other sociodemographic factors such as income and employment, tended to be associated with excessive GWG.[12] However, previous findings were mainly limited to developed Western settings,[12] which may not be generalizable to other regions with different sociodemographic backgrounds and cultural behaviors. Moreover, previous studies rarely included different aspects of sociodemographic status relevant to other demographics, such as household occupancy.

The United Arab Emirates (UAE) is a high-income Arab country with a relatively homogeneous native Emirati population.[13] Previous research has shown that the Middle East region has a high prevalence of overweight and obesity, especially amongst women.[14-16] Studies in the UAE have shown that approximately two-thirds of Emirati women were classified as overweight or obesity; however, these cross-sectional designs were unable to elucidate the risk factors for weight gain.[17,18] Due to the cultural practices and religious beliefs of women in the UAE, the prevalence of tobacco smoking[19] and alcohol consumption is extremely low.[17] However, a birth cohort of Emirati and Arab women in the UAE reported that more than half of women with overweight or obesity, and almost three-quarters of pregnant women had inadequate and excessive GWG.[20] This study did not find any association between maternal education, employment status, or monthly family income and prepregnancy BMI or GWG among the UAE pregnant women; however, the sample size was small ($N = 256$) and the analysis may have been underpowered for this specific analysis.[20] A recent systematic review on maternal and child cohorts in the Gulf Cooperation Council countries including the UAE highlighted a lack of research on GWG in the region.[21] As can be seen by previous literature mentioned above, overweight and obesity is an important public health issue in the UAE, and its effects on GWG in pregnancy needs to be thoroughly understood using the robust longitudinal cohort design with a large representative sample. Hence, this study aims to investigate the associations between sociodemographic and lifestyle factors and prepregnancy BMI and GWG in the largest mother and child prospective cohort study in the UAE. It was hypothesized that women with overweight or obesity before pregnancy would be more likely to have poorer lifestyle factors and unhealthy GWG during their current pregnancy.

## 2 | METHODS

### 2.1 | Study participants

The Mutaba'ah (meaning "follow-up" in Arabic) study is an ongoing prospective cohort study in Al Ain city, UAE, that plans to follow the mothers and their offspring until the child turns 16 years of age.[22] Since 2017, pregnant women (at any week of gestation) have been recruited from the three major hospitals in Al Ain (7690 pregnant women were recruited as of November 2020). The recruitment criteria included: women from the Emirati population resident in Al Ain, at least 18 years old, inclusion of their newborn(s) and being able to provide informed consent. Participants' information was ascertained from medical records and using tablet-assisted self-administered questionnaires in Arabic. Further details of the study design have been described elsewhere.[22] Ethical approval for this cohort study was obtained from the UAE University Human Research Ethics Committee (previously known as Al Ain Medical District Human Research Ethics Committee) (ERH-2017-5512), Al Ain Hospital Research Ethics Committee (AAHEC-03-17-058), and Tawam Human Research Ethics Committee (T-HREC-494).

### 2.2 | Sociodemographic and lifestyle factors

A wide range of indicators including maternal education, occupation (i.e. employment status) and income (i.e., type of housing, housing ownership, and number of residents in household) reported at the recruitment visit were used to represent different aspects of sociodemographic status.[23] While education might indicate both knowledge-related assets and economic resources and status, occupation might reflect status, prestige, or community ranking.[24,25] Income related variables might represent wealth or material aspects of sociodemographic status and assets.[24,25]

Maternal highest education was classified into: 1) none/primary/secondary education, 2) postsecondary education including vocational and diploma degree and 3) tertiary education including bachelor, master, and doctoral degrees. Responses on employment status were recorded as: 1) student/unemployed/retired, 2) housewife, or 3) employed/self-employed.

Pregnant women's housing type (standalone homes [these are government initiative housing] apartment, part of a villa, and villa) and ownership (rented, owned) was used as an economic indicator. Pregnant women were asked to indicate the number of residents living in their household, which were categorized into tertiles (≤6, 7–12, and ≥13 people). Parity was also included as part of sociodemographic measures, classified into nulliparous, multiparous (1–2, 3–4 children) and grand multiparous (≥5 children).

Lifestyle factors that are likely to precede pregnancy were also included in the analyses. Pregnant women provided binary responses (yes or no) on pregnancy planning status and infertility treatment status at recruitment visit. Prepregnancy maternal and husband's active smoking status, ranging from never to regularly, were also recorded.

## 2.3 | Prepregnancy BMI and GWG

Information on maternal age and on repeated measures of maternal weight before and during pregnancy and maternal height were extracted from medical records. Prepregnancy maternal weight was defined as the most contemporaneous body mass between eight weeks before pregnancy and first month of pregnancy.

Since gestational weight was serially measured across a wide range of gestational ages, the estimation of total GWG is subject to varying gestational age intervals between the first and last measures. Therefore, random coefficient modeling of weight measures during pregnancy between first and third trimester was computed. This model generates the individual Best Linear Unbiased Predictor values of the random intercept (i.e., the difference between the person-specific intercept and the overall intercept) and random slope (i.e., the difference between person-specific slope and the overall slope).[26] The individual linear trajectories of GWG per week from gestational age at 8 weeks to delivery was then estimated by adding the overall slope to the individual random slopes. Similarly, prepregnancy weight was estimated by summing the overall intercept and the individual random intercepts from the same model. Given the high correlation between the estimated and the measured prepregnancy BMI (Pearson's correlation coefficient = 0.97), the estimated prepregnancy weight was used for women with missing ($n$ = 1658) data on the prepregnancy weight.

The GWG per week was categorized into i) inadequate, ii) adequate, or iii) excessive for a given prepregnancy BMI status, according to the IOM's guidelines.[2] The adequate range of GWG per week was considered as: 0.44–0.58 kg for women with underweight, 0.35–0.50 kg for women with normal weight, 0.23–0.33 kg for women with overweight, and 0.17–0.27 kg for women with obesity.[2] GWG below or above these weight gain ranges for a given prepregnancy BMI status were considered as an inadequate or excessive gain, respectively.

## 2.4 | Statistical analyses

This study included pregnant women who had delivered and had data on both prepregnancy weight status and rate of GWG. The differences in socioeconomic determinants across prepregnancy BMI and GWG adequacy were compared using chi-squared tests for categorical variables and one-way analysis of variance tests for continuous variables.

To explore associations between sociodemographic determinants and prepregnancy BMI (as a continuous outcome), multivariable linear regression models with adjustment for maternal age at delivery were computed. The regression coefficients ($\beta$) with their 95% confidence interval (CI) were reported to demonstrate the unit change of BMI associated with changes in each of the sociodemographic and lifestyle factors. Similarly, the associations between sociodemographic determinants and GWG adequacy were tested using multivariable multinomial logistic regression, with adequate GWG as the reference category. For logistic regression models, odds ratios (ORs) with 95% CI were reported. These models were conducted i) separately in women with prepregnancy normal, overweight, and obesity weight status, adjusted for maternal age at delivery and ii) in all women, adjusted for maternal age at delivery, and prepregnancy BMI. Further adjustment by including all sociodemographic determinants in the same models were performed. To allow comparisons of findings across sociodemographic determinants, multiple imputation by chained equations with 50 datasets were performed to impute missing sociodemographic determinants ($n$ = 221–428, 6.3%–12.1%).

All statistical analyses were performed using Stata 15.1 (StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC). Statistical significance was defined by a $p \leq 0.05$ and 95% confidence intervals.

# 3 | RESULTS

## 3.1 | Participants' characteristics

As of November 2020, 4399 pregnant women had given birth and 3536 (80.4%) pregnant women were included in the present analysis. Those excluded were due to missing data on both prepregnancy BMI and GWG ($n$ = 854) or on only GWG ($n$ = 9). Compared to the excluded population, included women were older, multiparous, lower educated, and housewives. They were also more likely to live in a rented apartment, have planned their pregnancy, have had infertility treatment, and have a husband who did not smoke before pregnancy (Supplementary Table S1).

Among the included pregnant women, the mean age at recruitment and the mean prepregnancy BMI of pregnant women were 31.4 ± 6.1 years old and 26.8 ± 5.9 kg/m$^2$, respectively. Based on the prepregnancy BMI, one-third (33.5%) of pregnant women were classified as normal weight, followed by one-third (33.2%) classified as overweight, 26.9% as obesity, and 6.4% as underweight. More than one-quarter (27.6%) of pregnant women were considered to have an adequate rate of GWG, while approximately one-third (34.2%) each had an inadequate or excessive (38.2%) rate of GWG. Women with overweight and obesity were more likely to have excessive GWG rate (49.9% and 48.8% vs. 18.6% and 21.8%) than women with underweight and normal weight (Figure 1).

Table 1 shows the comparisons of pregnant women's characteristics across prepregnancy BMI and GWG adequacy. Compared to women with underweight (mean age ± SD: 26.8 ± 4.6 years) and normal weight (29.7 ± 5.6 years), women with overweight (32.1 ± 5.9 years), and obesity (33.6 ± 5.8 years) tended to be older. They also had a greater prevalence of grand multiparity (19.4% [overweight] and 24.6% [obesity] vs. 3.9% [underweight] and 11.3% [normal weight]), and lower proportions of them were educated (tertiary: 39.2% and 34.0% vs. 41.7% and 45.4%), employed or self-employed (34.7% and 37.1% vs. 15.0% and 29.2%), and more frequently had previous infertility treatment (12.3% and 14.8% vs. 5.2% and 8.4%) (Table 1). Furthermore, pregnant women with excessive GWG rate were less likely to be grand multiparous (14.5% vs. 15.7% [adequate] and 20.7% [inadequate]) but more likely to be younger (mean age: 30.8 ± 6.0 vs. 31.1 ± 6.0 and 32.1 ± 6.1 years) and have planned their pregnancy [59.4% vs. 56.2% and 54.2%], than their counterparts with adequate or inadequate GWG rate, respectively.

## 3.2 | Sociodemographic factors and prepregnancy BMI

Supplemental Table S2 and Figure 2 show the adjusted associations of sociodemographic and lifestyle factors with prepregnancy BMI. Higher parity ($\beta$ for 1–2 (vs. none): 0.92 kg/m$^2$, 95% CI: 0.36–1.48; 3–4: 1.48 kg/m$^2$, 95% CI: 0.84–2.012; ≥5: 1.71 kg/m$^2$, 95% CI: 0.88–2.54), having previous infertility treatment ($\beta$: 0.69 kg/m$^2$, 95% CI: 0.08–1.30), prepregnancy maternal active smoking ($\beta$: 1.95 kg/m$^2$, 95% CI: 0.42–3.49) and prepregnancy husband's active smoking ($\beta$: 0.53 kg/m$^2$, 95% CI: 0.07–1.00) were linearly associated with higher prepregnancy BMI ($p < 0.05$). Additionally, higher levels of maternal education were linearly associated with lower prepregnancy BMI ($\beta$ for tertiary: −1.42 kg/m$^2$, 95% CI: −1.82 to −1.02). Owning compared to renting a flat was associated with higher prepregnancy BMI ($\beta$: 0.93 kg/m$^2$, 95% CI: 0.03–1.82). Similar findings were seen in the mutual adjustment model except for prepregnancy husband's active smoking and house type (Supplementary Table S2).

## 3.3 | Sociodemographic factors and GWG

Table 2 shows the adjusted associations of sociodemographic and lifestyle factors with GWG rate classification by prepregnancy BMI status. Among women with normal weight (Table 2), higher parity was linearly associated with a lower risk for excessive GWG (OR for 1–2 (vs. none): 0.61, 95% CI: 0.41–0.91; OR for 3–4: 0.50, 95% CI: 0.29–0.85; OR for ≥5: 0.39, 95% CI: 0.17–0.90). Higher education level was linearly and marginally associated with lower risk for inadequate GWG (OR for tertiary: 0.75, 95% CI: 0.57–1.00). Pregnant women living in a household with 7–12 (vs. ≤6) (OR for: 0.62, 95% CI: 0.41–0.93) and ≥13 (OR for: 0.65, 95% CI: 0.43–0.97) occupants were associated with a lower risk for excessive GWG, but these associations were not linear. Among women with overweight, a

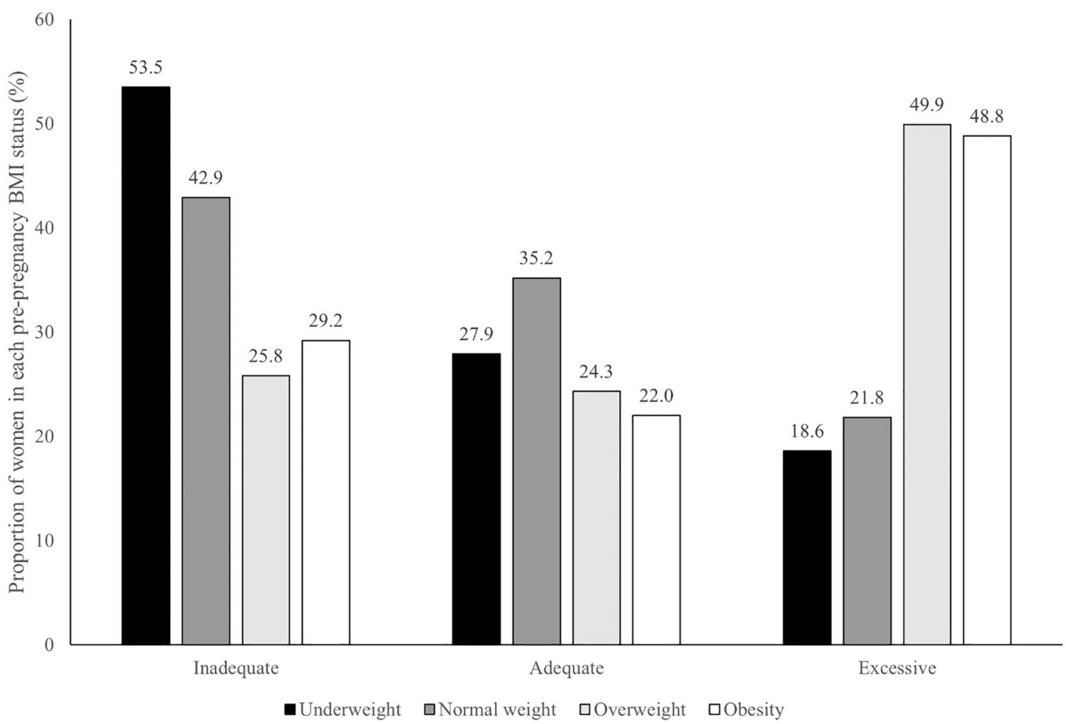


FIGURE 1 Gestational weight gain stratified by prepregnancy BMI status among pregnant women in Al Ain, UAE: The Mutaba'ah study

**TABLE 1** Comparisons of characteristics across pregnant women's prepregnancy BMI status and gestational weight gain adequacy among pregnant women in Al Ain, UAE: The Mutaba'ah study

| | Prepregnancy BMI Status | | | | | Gestational weight gain rate | | | |
|---|---|---|---|---|---|---|---|---|---|
| Characteristics | Underweight ($n$ = 226) Mean ± SD | Normal ($n$ = 1186) Mean ± SD | Overweight ($n$ = 1174) Mean ± SD | Obesity ($n$ = 950) Mean ± SD | $p$ value | Inadequate ($n$ = 1210) Mean ± SD | Adequate ($n$ = 975) Mean ± SD | Excessive ($n$ = 1351) Mean ± SD | $p$ value |
| Age at delivery, years | 26.8 ± 4.6 | 29.7 ± 5.6 | 32.1 ± 5.9 | 33.6 ± 5.8 | <0.001 | 32.1 ± 6.1 | 31.1 ± 6.0 | 30.8 ± 6.0 | <0.001 |
| Prepregnancy body mass index, kg/m$^2$ | 16.9 ± 1.3 | 22.1 ± 1.8 | 27.4 ± 1.4 | 34.2 ± 4.0 | <0.001 | 26.1 ± 6.5 | 25.8 ± 5.6 | 28.1 ± 5.3 | <0.001 |
| Gestational weight gain per week, kg | 0.44 ± 0.16 | 0.39 ± 0.16 | 0.34 ± 0.18 | 0.27 ± 0.19 | <0.001 | 0.18 ± 0.13 | 0.34 ± 0.10 | 0.49 ± 0.14 | <0.001 |
| | $n$ (%) | $n$ (%) | $n$ (%) | $n$ (%) | | $n$ (%) | $n$ (%) | $n$ (%) | |
| Parity | | | | | <0.001 | | | | <0.001 |
| 0 | 89 (43.0) | 307 (29.4) | 164 (15.9) | 108 (13.1) | | 188 (17.5) | 193 (22.5) | 287 (24.5) | |
| 1–2 | 87 (42.0) | 381 (36.4) | 351 (34.0) | 253 (30.8) | | 361 (33.6) | 296 (34.5) | 415 (35.4) | |
| 3–4 | 23 (11.1) | 240 (22.9) | 318 (30.8) | 259 (31.5) | | 303 (28.2) | 235 (27.4) | 302 (25.7) | |
| ≥5 | 8 (3.9) | 118 (11.3) | 200 (19.4) | 202 (24.6) | | 223 (20.7) | 135 (15.7) | 170 (14.5) | |
| Maternal education | | | | | <0.001 | | | | 0.081 |
| None/primary/secondary school | 107 (50.7) | 499 (45.2) | 560 (51.7) | 485 (55.3) | | 595 (52.8) | 428 (47.0) | 628 (50.7) | |
| Postsecondary | 16 (7.6) | 104 (9.4) | 98 (9.1) | 94 (10.7) | | 109 (9.6) | 85 (9.3) | 119 (9.6) | |
| Tertiary | 88 (41.7) | 502 (45.4) | 425 (39.2) | 298 (34.0) | | 423 (37.6) | 398 (43.7) | 492 (39.7) | |
| Employment | | | | | <0.001 | | | | 0.309 |
| Student/unemployed/retired | 68 (31.9) | 209 (18.9) | 137 (12.7) | 81 (9.2) | | 155 (13.8) | 151 (16.6) | 189 (15.2) | |
| Housewife | 113 (53.1) | 573 (51.9) | 568 (52.6) | 471 (53.6) | | 616 (54.8) | 459 (50.5) | 650 (52.4) | |
| Employed/self-employed | 32 (15.0) | 322 (29.2) | 375 (34.7) | 326 (37.1) | | 354 (31.5) | 299 (32.9) | 402 (32.4) | |
| House type | | | | | 0.156 | | | | 0.487 |
| Rented flat/apartment/ standalone home | 15 (7.2) | 75 (7.0) | 60 (5.7) | 55 (6.4) | | 74 (6.7) | 56 (6.4) | 75 (6.1) | |
| Rented part of a villa/villa | 18 (8.6) | 156 (14.6) | 133 (12.6) | 124 (14.4) | | 158 (14.4) | 127 (14.4) | 146 (12.0) | |
| Owned flat/apartment/ standalone home | 25 (12.0) | 148 (13.8) | 173 (16.3) | 133 (15.5) | | 167 (15.2) | 135 (15.3) | 177 (14.5) | |
| Owned part of a villa/villa | 151 (72.3) | 693 (64.7) | 694 (65.5) | 548 (63.7) | | 701 (63.7) | 562 (63.9) | 823 (67.4) | |
| Number of residents in household | | | | | 0.127 | | | | 0.054 |
| ≤6 | 68 (33.0) | 307 (28.9) | 309 (29.6) | 259 (30.5) | | 339 (31.4) | 228 (25.9) | 376 (31.3) | |
| 7–12 | 66 (32.0) | 376 (35.4) | 415 (39.8) | 305 (36.0) | | 385 (35.6) | 337 (38.3) | 440 (36.6) | |
| ≥13 | 72 (35.0) | 380 (35.8) | 320 (30.7) | 284 (33.5) | | 357 (33.0) | 314 (35.7) | 385 (32.1) | |
| Planned pregnancy | | | | | 0.886 | | | | 0.035 |
| No | 97 (45.5) | 472 (42.7) | 473 (43.2) | 387 (43.6) | | 522 (45.8) | 395 (43.8) | 512 (40.6) | |
| Yes | 116 (54.5) | 634 (57.3) | 623 (56.8) | 501 (56.4) | | 618 (54.2) | 507 (56.2) | 749 (59.4) | |
| Infertility treatment | | | | | <0.001 | | | | 0.160 |
| No | 199 (94.8) | 1005 (91.6) | 945 (87.7) | 746 (85.2) | | 1012 (90.1) | 792 (88.7) | 1091 (87.6) | |
| Yes | 11 (5.2) | 92 (8.4) | 133 (12.3) | 130 (14.8) | | 111 (9.9) | 101 (11.3) | 154 (12.4) | |

TABLE 1 (Continued)

| | *n* (%) | *n* (%) | *n* (%) | *n* (%) | | *n* (%) | *n* (%) | *n* (%) | |
|---|---|---|---|---|---|---|---|---|---|
| Prepregnancy maternal active smoking | | | | | 0.052 | | | | 0.209 |
| Never | 216 (100.0) | 1095 (98.8) | 1085 (98.1) | 865 (97.7) | | 1124 (98.4) | 903 (98.9) | 1234 (97.9) | |
| Occasionally/regularly | 0 (0.0) | 13 (1.2) | 21 (1.9) | 20 (2.3) | | 18 (1.6) | 10 (1.1) | 26 (2.1) | |
| Prepregnancy husband's active smoking | | | | | 0.616 | | | | 0.947 |
| Never | 133 (61.6) | 664 (59.8) | 647 (58.7) | 520 (58.9) | | 672 (58.8) | 548 (60.3) | 744 (59.1) | |
| Occasionally | 38 (17.6) | 182 (16.4) | 197 (17.9) | 136 (15.4) | | 190 (16.6) | 147 (16.2) | 216 (17.1) | |
| Regularly | 45 (20.8) | 264 (23.8) | 258 (23.4) | 227 (25.7) | | 280 (24.5) | 214 (23.5) | 300 (23.8) | |

higher educational level (OR for tertiary: 0.69, 95% CI: 0.48–0.99) and infertility treatment (OR: 0.55, 95% CI: 0.33–0.92) were associated with a lower risk for inadequate GWG. Among women with obesity, owning a villa (or part of) was the only factor associated with excessive GWG (OR: 2.33, 95% CI: 1.22–4.44). In mutual adjustment models (Supplemental Tables S3–S5), the associations for parity, infertility treatment, and house type among women with normal weight, overweight and obesity remained, respectively.

Overall, higher parity and higher education level were linearly associated with lower risks for excessive GWG and inadequate GWG, respectively. These findings remained in mutual adjustment model (Supplemental Table S4).

## 4 | DISCUSSION

In this large prospective cohort study, higher parity, lower maternal education, history of infertility treatment, and prepregnancy maternal and husband's active smoking, were all associated with a higher prepregnancy BMI. There were linear inverse associations of parity and maternal education with excessive and inadequate GWG risk, respectively, especially among women with normal weight and overweight. No sociodemographic indicator was linearly related to GWG among women with obesity.

The present study revealed that more than half of the population in the present cohort had overweight and obesity prior to conception. More than two-thirds of pregnant women did not meet weight gain recommendations during pregnancy, including both inadequate and excessive weight gain. Therefore, early initiation and regular antenatal care visits are vital to ensure that pregnant women in the UAE achieve an adequate rate of GWG,[27] to optimize overall maternal and pregnancy outcomes. Such an approach is supported by previous studies which reported that both women and health care professionals agreed that discussions about weight gain during pregnancy should begin from early pregnancy and continue throughout the postpartum period.[27,28] However, previous work from our research group has shown that approximately 50% of women in this current cohort were late in initiating (>4 months' gestation) their antenatal care, highlighting the need to increase interactions between healthcare workers and pregnant women through an array of implementations.[29] Electronic-health provision has proven to be feasible and lead to an increase in self-efficacy of dietary change and readiness to exercise.[30] Moreover, social media interventions have been shown to improve health literacy and may be a preferable alternative to traditional face-to-face lifestyle counseling, especially for those women who feel stigmatized for having certain lifestyle behaviors or diseases during pregnancy.[31,32] Whether these strategies would be effective in eliciting healthy behavior change in the UAE context deserves further studies.

The present findings showed some consistency with previous studies across different countries.[12,20,33,34] Our observation is comparable to a meta-analysis of 14 studies mainly in Western settings which showed positive relationships between parity and prepregnancy BMI.[33] The Mother and Infant Nutritional Assessment cohort in Lebanon ($n$ = 194) and Qatar ($n$ = 147) demonstrated that higher parity and lower educational level but not employment status and prepregnancy smoking were associated with a higher risk for overweight and obesity before pregnancy, but the association remained only for maternal education after considering other characteristics such as age, nationality, and parity.[34] A previous study in the UAE also found multiparous women were associated with higher prepregnancy BMI but this association disappeared after adjustment for maternal age possibly due to insufficient statistical power ($n$ = 256) and/or confounding.[20] However, this relationship remained robust after adjustment in the present study with a much larger and adequately powered sample size ($n$ = 3536).

We further extended the previous UAE study which reported that multiparous women were associated with a lower risk of excessive GWG but not inadequate GWG,[20] by showing the negative associations between parity and excessive GWG particularly among women with normal weight. The present study and a systematic review also reported that women's education level rather than other sociodemographic indicators including employment was associated with GWG.[12] Conversely, the review found more studies that showed women with lower educational levels tended to have excessive GWG,[12] instead of the inadequate GWG observed in our study. The meta-analysis of 17 studies mainly in Western settings did not find an association between parity and GWG.[33] A lack of association

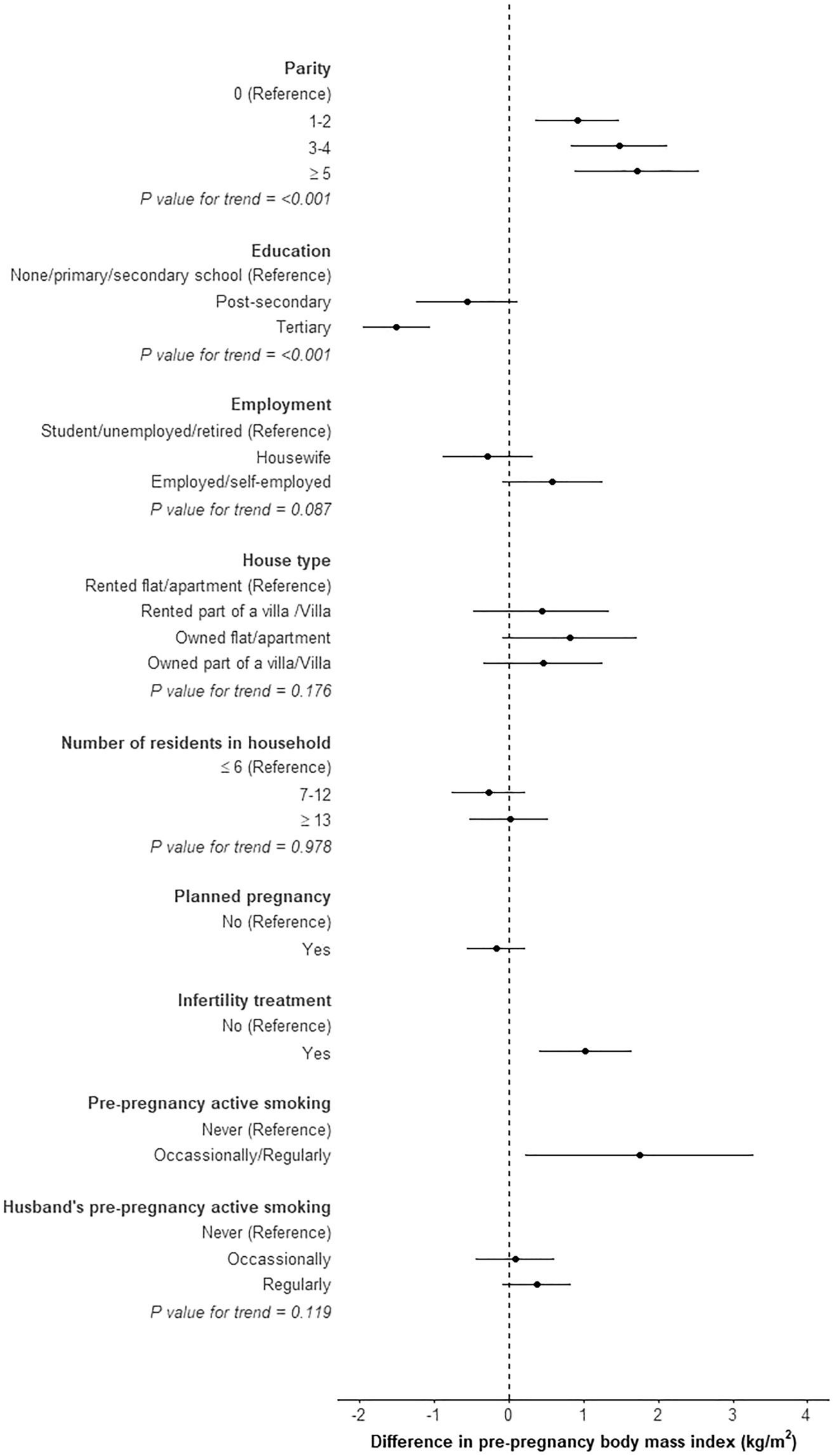


**FIGURE 2** Factors associated with prepregnancy body mass index in pregnant women in Al Ain, UAE: The Mutaba'ah study

between parity, maternal education, employment status, and pre-pregnancy active smoking and inadequate and excessive GWG was reported in Lebanon and Qatar as well.[34] The discrepancy between the present and previous findings could be that GWG rate estimates in the Mutaba'ah study were considerations of repeated weight measures throughout pregnancy and gestational ages at weight measurements using random coefficient modeling, whereas previous studies were limited to calculating GWG as the difference between weights before pregnancy and delivery, which is subject to the time interval between both measures.[12,20,33,34]

Using a wide range of sociodemographic and lifestyle factors, we demonstrated that lower education level, higher parity, prepregnancy maternal and husband's active smoking were associated with a higher prepregnancy BMI. Conversely, a lower education level and higher parity were associated with inadequate GWG or less likely with excessive GWG among women with normal weight and overweight.

**TABLE 2** Associations of socioeconomic and lifestyle factors with inadequate and excessive (vs. adequate) gestational weight gain rate by prepregnancy BMI status, with multiple imputation by chained equation among pregnant women in Al Ain, UAE: The Mutaba'ah study

| | Normal weight ($n$ = 1186) | | | | Overweight ($n$ = 1174) | | | | Obese ($n$ = 950) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Inadequate | | Excessive | | Inadequate | | Excessive | | Inadequate | | Excessive | |
| Characteristics | Adjusted OR (95% CI)[a] | $p$ value | Adjusted OR (95% CI)[a] | $p$ value | Adjusted OR (95% CI)[a] | $p$ value | Adjusted OR (95% CI)[a] | $p$ value | Adjusted OR (95% CI)[a] | $p$ value | Adjusted OR (95% CI)[a] | $p$ value |
| Parity | | | | | | | | | | | | |
| 0 | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – |
| 1–2 | 1.23 (0.86, 1.76) | 0.266 | 0.61 (0.41, 0.91) | 0.015 | 0.87 (0.49, 1.56) | 0.650 | 0.88 (0.55, 1.40) | 0.585 | 1.19 (0.62, 2.31) | 0.597 | 0.84 (0.47, 1.51) | 0.560 |
| 3–4 | 1.25 (0.81, 1.94) | 0.309 | 0.50 (0.29, 0.85) | 0.010 | 1.10 (0.61, 2.01) | 0.747 | 0.69 (0.42, 1.14) | 0.150 | 1.09 (0.55, 2.13) | 0.810 | 0.94 (0.52, 1.72) | 0.848 |
| ≥5 | 1.42 (0.80, 2.51) | 0.229 | 0.39 (0.17, 0.90) | 0.027 | 1.31 (0.66, 2.56) | 0.444 | 0.71 (0.39, 1.30) | 0.262 | 1.20 (0.57, 2.55) | 0.627 | 0.89 (0.45, 1.74) | 0.725 |
| $p$ value for trend | | 0.012 | | <0.001 | | 0.036 | | 0.024 | | 0.501 | | 0.558 |
| Maternal education | | | | | | | | | | | | |
| None/primary/secondary school | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – |
| Postsecondary | 1.03 (0.63, 1.69) | 0.897 | 1.46 (0.81, 2.64) | 0.211 | 0.62 (0.33, 1.16) | 0.132 | 1.00 (0.60, 1.69) | 0.990 | 1.07 (0.58, 1.98) | 0.820 | 0.95 (0.53, 1.70) | 0.852 |
| Tertiary | 0.75 (0.57, 1.00) | 0.049 | 1.17 (0.82, 1.65) | 0.386 | 0.69 (0.48, 0.99) | 0.041 | 0.99 (0.72, 1.35) | 0.953 | 0.68 (0.45, 1.03) | 0.067 | 1.00 (0.70, 1.44) | 0.998 |
| $p$ value for trend | | 0.009 | | 0.060 | | 0.014 | | 0.175 | | 0.018 | | 0.158 |
| Employment | | | | | | | | | | | | |
| Student/unemployed/retired | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – |
| Housewife | 1.15 (0.78, 1.70) | 0.472 | 1.25 (0.80, 1.95) | 0.319 | 0.96 (0.55, 1.69) | 0.896 | 1.26 (0.77, 2.03) | 0.355 | 1.39 (0.66, 2.95) | 0.388 | 1.01 (0.54, 1.86) | 0.986 |
| Employed/self-employed | 0.88 (0.57, 1.37) | 0.582 | 1.33 (0.79, 2.22) | 0.282 | 0.79 (0.43, 1.45) | 0.444 | 1.17 (0.69, 1.97) | 0.555 | 1.31 (0.60, 2.87) | 0.500 | 0.99 (0.52, 1.89) | 0.984 |
| $p$ value for trend | | 0.269 | | 0.140 | | 0.207 | | 0.210 | | 0.385 | | 0.582 |
| House type ($n$, %) | | | | | | | | | | | | |
| Rented flat/apartment/standalone home | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – |
| Rented part of a villa/Villa | 0.71 (0.37, 1.36) | 0.302 | 0.55 (0.24, 1.25) | 0.155 | 0.63 (0.25, 1.56) | 0.314 | 0.857(0.26, 1.26) | 0.165 | 1.83 (0.79, 4.26) | 0.160 | 1.63 (0.77, 3.47) | 0.203 |
| Owned flat/Apartment/Stand alone home | 0.83 (0.43, 1.61) | 0.590 | 0.78 (0.35, 1.72) | 0.532 | 0.66 (0.27, 1.58) | 0.349 | 0.52 (0.24, 1.15) | 0.105 | 1.74 (0.76, 4.01) | 0.190 | 1.61 (0.76, 3.42) | 0.210 |
| Owned part of a villa/villa | 0.65 (0.37, 1.16) | 0.142 | 0.70 (0.36, 1.40) | 0.316 | 0.75 (0.33, 1.68) | 0.483 | 0.65 (0.31, 1.33) | 0.237 | 2.01 (0.97, 4.17) | 0.060 | 2.33 (1.22, 4.44) | 0.010 |
| $p$ value for trend | | 0.297 | | 0.917 | | 0.874 | | 0.270 | | 0.639 | | 0.092 |

(Continues)

TABLE 2 (Continued)

| Characteristics | Normal weight ($n$ = 1186) | | | | Overweight ($n$ = 1174) | | | | Obese ($n$ = 950) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Inadequate | | Excessive | | Inadequate | | Excessive | | Inadequate | | Excessive | |
| | Adjusted OR (95% CI)[a] | $p$ value | Adjusted OR (95% CI)[a] | $p$ value | Adjusted OR (95% CI)[a] | $p$ value | Adjusted OR (95% CI)[a] | $p$ value | Adjusted OR (95% CI)[a] | $p$ value | Adjusted OR (95% CI)[a] | $p$ value |
| Number of residents in household | | | | | | | | | | | | |
| ≤6 | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – |
| 7–12 | 0.79 (0.56, 1.11) | 0.168 | 0.62 (0.41, 0.93) | 0.020 | 0.83 (0.55, 1.27) | 0.394 | 0.80 (0.55, 1.15) | 0.227 | 0.70 (0.43, 1.34) | 0.139 | 0.93 (0.60, 1.44) | 0.736 |
| ≥13 | 0.82 (0.58, 1.16) | 0.262 | 0.65 (0.43, 0.97) | 0.035 | 0.99 (0.63, 1.56) | 0.978 | 0.88 (0.59, 1.31) | 0.532 | 0.70 (0.44, 1.13) | 0.144 | 0.73 (0.47, 1.14) | 0.166 |
| $p$ value for trend | | 0.862 | | 0.075 | | 0.671 | | 0.444 | | 0.447 | | 0.535 |
| Planned pregnancy | | | | | | | | | | | | |
| No | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – |
| Yes | 0.83 (0.63, 1.09) | 0.177 | 0.98 (0.70, 1.36) | 0.890 | 1.12 (0.80, 1.56) | 0.523 | 1.25 (0.93, 1.68) | 0.147 | 0.92 (0.63, 1.34) | 0.671 | 1.23 (0.87, 1.74) | 0.240 |
| Infertility treatment | | | | | | | | | | | | |
| No | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – |
| Yes | 0.65 (0.40, 1.05) | 0.077 | 0.96 (0.53, 1.74) | 0.886 | 0.55 (0.33, 0.92) | 0.024 | 0.89 (0.58, 1.37) | 0.596 | 1.59 (0.90, 2.80) | 0.112 | 1.67 (0.98, 2.86) | 0.061 |
| Prepregnancy maternal active smoking | | | | | | | | | | | | |
| Never | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – |
| Occasionally/regularly | 1.00 (0.26, 3.77) | 0.998 | 1.69 (0.41, 7.01) | 0.469 | 3.59 (0.75, 17.08) | 0.109 | 2.79 (0.61, 12.72) | 0.185 | 0.96 (0.26, 3.60) | 0.957 | 1.08 (0.34, 3.45) | 0.899 |
| Prepregnancy husband's active smoking | | | | | | | | | | | | |
| Never | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – | 1.00 | – |
| Occasionally | 0.92 (0.63, 1.34) | 0.664 | 0.92 (0.59, 1.44) | 0.715 | 1.32 (0.83, 2.10) | 0.239 | 1.34 (0.89, 2.01) | 0.159 | 1.35 (0.79, 2.30) | 0.271 | 0.93 (0.56, 1.56) | 0.790 |
| Regularly | 1.06 (0.77, 1.47) | 0.716 | 0.80 (0.53, 1.20) | 0.277 | 1.28 (0.84, 1.94) | 0.246 | 1.20 (0.83, 1.73) | 0.331 | 1.08 (0.69, 1.68) | 0.743 | 0.94 (0.63, 1.40) | 0.766 |
| $p$ value for trend | | 0.347 | | 0.155 | | 0.462 | | 0.711 | | 0.522 | | 0.524 |

[a]Adjusted for maternal age.

Similarly, an increased number of household members was less likely to be associated with excessive GWG in women with normal weight, despite the lack of linearity. This may be likely explained by higher parity, as seen in the mutual adjustment model. We included parity as part of the sociodemographic indicators since grand multiparity has been associated with a lower sociodemographic status due to sociocultural reasons such as poor awareness of modern family planning methods.[35,36] However, given linear associations of parity with prepregnancy BMI and GWG in the present study, it may suggest there could be a biological effect of parity such as weight retention after each pregnancy. Our findings also suggest that women with lower levels of formal schooling in the UAE may lack health literacy of appropriate weight management strategies before and during pregnancy. The lack of health literacy can possibly undermine not only weight management in pregnancy, but also lead to other adverse pregnancy and delivery outcomes. Another study of the current cohort found that there was a lack of knowledge on mode of delivery.[37] This shows a pertinent need for robust, streamlined information to be shared and discussed with women of reproductive age in the UAE to improve knowledge and awareness of healthy conception and delivery including weight management.

We observed that owning and living in a larger house, which might suggest a higher sociodemographic status, tended to be associated with excessive GWG among women with obesity, although no linear relation was found. This observation could be elucidated by greater food intakes and reduced physical activity[38] or a misperception of obesity as a sign of high social status, beauty, fertility, and prosperity[39] among higher income families. Future health policies may want to consider increasing awareness on the consequences of obesity and excessive weight gain amongst all pregnant women in the UAE. Furthermore, it is important to educate women to maintain adequate weight gain during pregnancy within recommendations, rather than striving for weight loss during pregnancy which has been associated with a higher risk for small-gestational-for-age babies.[40]

Despite the large sample size, analyses of different sociodemographic and lifestyle factors and repeated measures of weight throughout pregnancy, this study contains several limitations. There were differences in characteristics between the included and excluded women, but the differences were modest and unlikely to influence the associations. Although a representative sample of women from the Emirati population was included, it was from only one city in the UAE, which may limit the generalizability of our findings to all pregnant women in the UAE or other regions. Nevertheless, Al Ain city has the largest proportion of the Emirati population in the UAE, ensuring that the sample remains representative of the nuances of the Emirati population.[22] Sociodemographic and lifestyle indicators were all self-reported, and hence, there may be a reporting bias due to different reasons such as social desirability, but this is expected to be nondifferential misclassifications. Prevalence of smoking among women could be underreported since it is considered a less socially acceptable behavior among women in the UAE. Also, the associations among underweight women could not be analyzed due to the current small sample size in this group.

In conclusion, this study revealed that sociodemographic factors were differentially associated with prepregnancy BMI and GWG. Higher parity and lower education level were consistently associated with higher prepregnancy BMI, but a higher risk of inadequate GWG and/or lower risk of excessive GWG especially among normal weight and overweight women. These findings will better inform the development of targeted interventions and policies that encourage women to attain and maintain a healthy weight status before and during pregnancy to optimize health outcomes for the mother and child.

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## CONFLICT OF INTEREST

The authors declared no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results. TSC's work is partially supported by the UK Medical Research Council (MC_UU_00006/2).

## AUTHOR CONTRIBUTIONS

L.A.A. and T.L. conceived the cohort study. N.A. and T.S.C. conceived the study. L.A.A, T.L, N.A and T.S.C. designed the study. N.A, T.S.C, L. A, T.L, I.E, F.A.M and R.H.A have worked on the methodology of the study. N.A. and T.S.C. analyzed data. L.A.A. and T.L. validated the analyses. N.A. and T.S.C. drafted the manuscript. L.A, T.L, I.E, F.A.M and R.H.A reviewed and edited the manuscript. L.A.A., T.L, and R.H.A contributed to funding acquisition. N.A, T.S.C, L.A, T.L, I.E, F.A.M and R.H.A have read and agreed to the published version of the manuscript.

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## SUPPORTING INFORMATION

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