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Biochemically confirmed smoking cessation and gestational weight gain

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Abstract

Background: Prenatal smoking cessation has substantial health benefits for mothers and offspring, but concerns about weight gain may be a barrier to quitting. We quantified gestational weight gain associated with biochemically confirmed smoking cessation.

Methods: Data originated from a randomized controlled cessation trial: Smoking Cessation in Pregnancy project (1987–1991). We calculated gestational weight gain using self-reported prepregnancy weight and measured weight at 30–34 weeks of gestation. We used linear regression to estimate adjusted mean differences in gain for quitters versus continuing smokers by the last trimester. The effects of quitting earlier (by 2nd trimester) versus later (by 3rd trimester) were calculated. We assessed the percentages who gained weight according to Institute of Medicine (IOM) recommendations within 2 weeks of a full-term delivery.

Results: At 30–34 weeks, nulliparous and multiparous quitters gained an average of 3.0 pounds (95% CI 0.9–5.1 pounds) (1.4 kg [0.4–2.3 kg]) and 6.6 pounds (95% CI 4.3–8.9 pounds) (3.0 kg [1.9–4.0 kg]) more, respectively, than continuing smokers. Weight gain in early quitters did not differ significantly from that in late quitters. Quitters were more likely than continuing smokers to gain above current guidelines (60.3% vs 46.3%) and were less likely to gain below guidelines (11.5% vs 21.6%) ($P = 0.002$).

Conclusions: Although quitters had modest additional weight gain by 30–34 weeks compared to continuing smokers, a high proportion in both groups gained in excess of IOM recommendations. Both quitters and continuing smokers may need support to achieve optimal gestational weight gain.

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DISCLAIMER

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Conversions: 1 pound = 0.45 kg.

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Keywords

pregnancy; smoking cessation; weight gain

1 | INTRODUCTION

It is well-established that smoking during pregnancy causes pregnancy complications and adverse birth outcomes.[1,2] Although there are substantial benefits from smoking cessation during pregnancy, including improvements in fetal growth and reduced preterm delivery risk,[2,3] the possibility of excess weight gain during pregnancy after cessation may be a barrier to cessation for some women.[4] Postcessation weight gain is well-described in the general smoking population,[5] but fewer studies in pregnant women have reported increased gestational weight gain[6,7] and postpartum weight retention among quitters,[13] and even fewer studies use biochemically validated cessation measures. Because gestational weight gain above recommended levels may result in infants being born large-for-gestational age and puts both woman and offspring at increased risk for overweight/obesity,[14] it is important to help women manage gestational weight gain while encouraging smoking cessation.

In a 2013 meta-analysis,[15] two randomized control trials (RCTs) of psychosocial interventions evaluated gestational weight gain after smoking cessation.[7,8] The studies were small, and only one included biochemical validation of cessation status. To better inform clinical practice, the effects and timing of smoking cessation on gestational weight gain need to be further elucidated. Therefore, we conducted a secondary data analysis from a large RCT of a brief counseling intervention that included biochemical validation of smoking cessation. Our study objectives were to: (a) quantify the difference in weight gain between quitters and continuing smokers at 30–34 weeks of gestation and (b) assess the percentages of quitters and continuing smokers who gained outside the weight gain guidelines among women with a measured weight obtained within 2 weeks of a term delivery. Secondary objectives included exploring the effects of timing of smoking cessation on weight gain and the effects of smoking cessation on infant outcomes.

2 | METHODS

2.1 | Study population

We used data from the Smoking Cessation in Pregnancy project (1987–1991), a prospective RCT of women receiving antenatal care in public clinics in Colorado, Maryland, and Missouri. In this study, clinics were randomized to deliver the brief counseling intervention or to provide usual care. There was no effect of the intervention on biochemically verified smoking cessation; women who received the intervention did not have statistically higher cessation rates than those that did not receive the intervention. Detailed information about the study has been published elsewhere.[16] Briefly, all women at their first prenatal visit were screened for eligibility based on self-reported smoking status; women were enrolled if they smoked even a puff of a cigarette within 7 days of screening or within 7 days before thinking they were pregnant. Women filled out questionnaires and provided urine samples for cotinine testing during enrollment (first or second prenatal visit), around the 8-month

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prenatal care visit, and postpartum (6–12 weeks after delivery). Maternal age, race/ethnicity, marital status, educational level, parity, number of cigarettes per day, alcohol use during pregnancy, and hours per day of passive smoke exposure were obtained from questionnaires.

Initial inclusion criteria for the current analysis were receipt of care at a clinic with ≥15 women enrolled in original RCT, delivery of a singleton infant, and completion of the 8-month visit on or after 30 weeks' gestation (N = 4069; Figure 1). We then excluded women who were missing a smoking measure during pregnancy, data on prepregnancy weight, a weight measurement between 30 and 34 weeks of gestation, and a plausible gestational weight gain measure. Our final analytic sample was 2183 women. The gestational window of 30–34 weeks was chosen since it corresponded to a scheduled study protocol visit. Women whose weight measurements were taken after 34 weeks were excluded so that all gestational weight gain measurements were recorded within a comparable gestational window. For women in the extreme tails of the weight gain distribution at 30–34 weeks or within 2 weeks of delivery (lost more than 20 pounds or gained more than 100 pounds), gestational weight gain estimates were considered implausible. Cut points for outliers were consistent with data from surveillance systems.[17] Compared with included women, excluded women had higher proportions who were smokers at their last prenatal visit (91.0% vs 87.8%), lower proportions who reported any alcohol use during pregnancy (17.5% vs 20.4%), and who were enrolled in WIC (51.6% vs 68.5%; $P < 0.05$ for all comparisons). Included and excluded women did not differ by race/ethnicity, education, marital status, parity, prepregnancy body mass index (BMI), state of residence, or smoking status at study enrollment.

2.2 | Effects of cessation on gestational weight gain

To quantify the difference in gestational weight gain between quitters and continuing smokers, we calculated gestational weight gain as the difference between the weight measurement in the gestational window of 30–34 weeks and the prepregnancy weight. Maternal prepregnancy weight was self-reported at study enrollment. Weight at 30–34 weeks of gestation based on last menstrual period was measured by staff nurses during prenatal care visits. For women whose eighth-month clinical visit measurement was missing but who delivered in the gestational window of 30–34 weeks, the final delivery weight self-reported on the postpartum survey was used (N = 176). We categorized women by their smoking status at their last prenatal visit. Quitters were those with biochemically confirmed cessation based on urine cotinine below the active smoking threshold of ≤85 ng/mL adjusted for urine creatinine.[18] Continuing smokers were those who had cotinine levels above the threshold or reported active smoking on the corresponding questionnaire.

We compared maternal and infant characteristics by smoking status; chi-square tests were used to detect differences for categorical variables, and Wilcoxon-Mann-Whitney tests were used for non-normally distributed continuous variables. Because we were interested in possible heterogeneity in weight gain across strata of other covariates, we tested for statistical interaction of smoking status with prepregnancy BMI, maternal race, and parity; only parity interacted significantly with smoking status ($P = 0.04$). Models stratified by parity using an interaction term adjusted for race, prepregnancy BMI (as a continuous

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variable), and gestational age at weight measurement (N = 2180). Although tests for interaction between smoking status and prepregnancy BMI were not significant, we had decided a priori to also report gestational weight gain findings stratified by this variable because of its importance in gestational weight gain recommendations. Because the clinics, and not the women, were randomly assigned to the intervention status, in our models we used generalized estimating equations to account for clustered data.

In addition, we calculated mean weight gains and adjusted mean differences in weight gain by intervention status instead of smoking status. No interaction was found with any predictors and intervention status, so the final adjusted linear regression model included race, parity, prepregnancy BMI (as a continuous variable), and gestational age at the time of the weight measurement (N = 2180).

In our subanalysis to explore potential associations between weight gain and the timing of cessation, we further characterized women based on smoking status in the first or second trimester, and smoking status in the third trimester: early quitters (those who had quit in the first or second trimester and stayed smoke-free through the third trimester) and late quitters (those who had quit by the third trimester). Women with incomplete data on smoking status for these two gestational windows were excluded (N = 686), leaving 1497 for this subanalysis. Linear regression models included the same adjustments and interaction term as the model for overall weight gain.

2.3 | Smoking cessation and weight gain guidelines

To assess the percentage of quitters and continuing smokers who gained outside weight gain guidelines, we restricted to women who had a term delivery (≥37 weeks) and a weight weight measurement within 2 weeks of delivery (N = 1153). Gestational weight gain was calculated as the difference between last weight measured within 2 weeks of delivery and self-reported prepregnancy weight. Weight gain was categorized as below the 2009 Institute of Medicine's (IOM) recommendations, within recommendations, and above recomendations for underweight <18.5 kg/m^2 are 28–40 pounds or 12.7–18.1 kg, for normal weight 18.5–24.9 kg/m^2 are 25–35 pounds or 11.3–15.9 kg, for overweight 25.0–29.9 kg/m^2 are 15–25 pounds or 6.8–11.3 kg, and for obese ≥30.0 kg/m^2 are 11–20 pounds or 5.0–9.1 kg.[14] We repeated the analysis with the 1990 IOM guidelines—those that were in place at the time of the original trial—which used different BMI categorizations and did not provide an upper bound for appropriate weight gain for obese women. To classify gain above guidelines, we used the same upper bounds for overweight and obese women.

Mean final gestational weight gain and the percentages of weight gain falling below, within, and above the IOM guidelines were calculated by smoking status. The differences between quitters' and continued smokers' mean weight gain were assessed using linear regression; differences from 2009 IOM guidelines overall and stratified by prepregnancy BMI were assessed using chi-square tests ($P < 0.05$). Overweight and obese women were combined into one group due to small sample sizes. We repeated this analysis with the 1990 IOM guidelines, which were in place at the time of the original trial. As in our analysis of smoking status and mean gestational weight gain, we decided a priori to report our main outcome model findings stratified by prepregnancy BMI and calculate gestational weight

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gains, standard deviations (SD), and ranges by smoking status. We used multivariable linear regression to estimate adjusted mean differences and 95% confidence intervals (CI) in gestational weight gain between quitters and smokers adjusting for race, parity, and gestational age at the weight measurement.

2.4 | Smoking cessation and infant outcomes

Infant outcomes included mean birthweight, low birthweight (LBW; <2500 g), and macrosomia (≥4000 g; N = 2178). Infant birthweight was obtained from maternal interviews at the postpartum visit or from birth certificates. In the original trial, maternal interview was found to be accurate compared to birth certificates in a subanalysis of the trial data, with 76% of deliveries including a birthweight reported from both sources.[19] We calculated the mean infant birthweight and adjusted mean difference between quitters and smokers using multivariable linear regression. The percentage of LBW and macrosomic infants and adjusted odds ratios using multivariable logistic regression were calculated by smoking status. We were not interested in heterogeneity of birthweight across strata of other covariates, so no interaction terms were included. All birthweight models were adjusted similarly with the addition of passive smoke exposure since it is associated with reduced birthweight (N = 2161).[20]

Due to the hierarchical structure of data (the intervention was randomized at the clinic level), we used generalized estimating equations (GEE) to account for the within-clinic correlation in all of our analyses. However, since the intervention trial found no significant effect on cessation[16] and was not associated with weight gain, we did not control for intervention arm. All data were analyzed using SAS 9.3 (Cary, NC, USA) with statistical significance set at $P < 0.05$. The study was determined research not involving human subjects from review by the Centers for Disease Control and Prevention's Institutional Review Board.

3 | RESULTS

Of the 2183 women in the sample, 12.2% were confirmed quitters by the third trimester using biochemical validation. Compared to continuing smokers, quitters were younger on average and higher proportions were nulliparous and lived in Colorado versus Maryland or Missouri (Table 1). Lower proportions of quitters smoked six or more cigarettes a day at enrollment and reported secondhand smoke exposure during pregnancy. Continuing smokers and quitters had similar distributions for the timing of their weight measurement in the gestational window of 30–34 weeks ($P = 0.63$); on average, weight was measured for quitters at 32.4 weeks and continuing smokers at 32.3 weeks. When comparing women by intervention status, there was no difference in mean gestational weight gain; the adjusted mean difference between the intervention and the control arm was +0.4 pounds (95% CI −0.8 to 1.5) (+0.2 kg [−0.4 to 0.7 kg]).

3.1 | Effects of cessation on gestational weight gain

Gestational weight gain was higher in quitters than in continuing smokers in all prepregnancy BMI categories examined. Differences in adjusted means all reached statistical significance: Underweight quitters gained on average 2.6 pounds (0.2–5.0) (1.2 kg [0.1–2.2

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kg]) more, normal weight quitters gained on average 4.6 pounds (2.9–6.3) (2.1 kg [1.3–2.8 kg]) more, and overweight/obese quitters gained on average 4.6 pounds (1.0–8.1) (2.1 kg [0.5–3.7 kg]) more than continuing smokers. In analyses stratified by parity, nulliparous quitters gained on average 3.0 pounds (0.9–5.1) (1.4 kg [0.4–2.3 kg]) more at 30–34 weeks of gestation than nulliparous continuing smokers, and multiparous quitters gained on average 6.6 pounds (4.3–8.9) (3.0 kg [2.0–4.0 kg]) more than multiparous continuing smokers (Table 2).

Both early quitters and late quitters had higher average weight gain than continuing smokers after adjustment, regardless of parity; however, the gain among nulliparous early quitters did not reach statistical significance (Table 2). There was no significant difference in weight gain between early and late quitters. However, the sample sizes in this analysis were small and the confidence intervals wide.

3.2 | Smoking cessation and weight gain guidelines

Among women delivering at term with a weight measured within 2 weeks of delivery, quitters gained statistically more weight, on average 38.0 pounds (17.2 kg) compared to continuing smokers who gained on average 33.0 pounds (15.0 kg). Continuing smokers and quitters had similar distributions of the timing of their weight measurement before delivery ($P = 0.60$); both groups had their weight measured on average 0.8 weeks before birth. Quitters were less likely than smokers to gain below the 2009 IOM guidelines (11.5% vs 21.6%) and more likely to gain above guidelines (60.3% vs 46.3%; $P < 0.01$); however, the percentage gaining above guidelines was high in both groups (Figure 2). When stratified by prepregnancy BMI, normal weight and overweight/obese quitters all had significantly higher average weight gain than continuing smokers in the same BMI categories (Figure 2). Overweight/obese quitters and continuing smokers had the largest proportions gaining above guidelines, with 8 out of 10 overweight/obese quitters gaining in excess of recommendations. When comparing smoking status using the 1990 IOM guidelines, results were similar with weight gain above recommendations in both quitters and smokers (data not shown).

3.3 | Smoking cessation and infant outcomes

Infants born to quitters weighed 215.1 g (95% CI 139.7–290.5) more than infants born to smokers in adjusted analyses. Compared to smokers, quitters had a 2.2% point reduction in the percentage of LBW deliveries (8.6% vs 6.4%, respectively), although the adjusted odds ratio (0.84, 95% CI 0.52–1.36) was not statistically significant. Compared to smokers, quitters had a 7.3% point increase in macrosomic deliveries (4.7% vs 12.3%, respectively), and the adjusted odds ratio was significant (2.64, 95% CI 1.55–4.49). However, the sample size for adverse birth outcomes was small.

4 | DISCUSSION

Pregnant smokers who quit by the third trimester of pregnancy had modest increases in gestational weight gain by 30–34 weeks compared with continuing smokers, which was higher for multiparous than nulliparous women (6.6 pounds and 3.0 pounds, or 3.0 and

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1.4 kg, respectively). This finding was consistent in a subgroup of women who had weight measurements at the end of pregnancy. Quitting earlier as compared to later in pregnancy did not contribute to meaningful differences in weight gain by 30–34 weeks. Among women with a term delivery and weight measurements near delivery, a high percentage of both quitters and continuing smokers exceeded IOM weight gain recommendations (60.3% of quitters and 46.3% of continuing smokers). Compared with continuing smokers, a lower proportion of quitters gained weight below guidelines across all BMI levels, and infants born to quitters had more than a 2% point reduction in LBW but a 7.3% point increase in macrosomia.

Limited information exists in the published literature on gestational weight gain in the context of behavioral smoking cessation interventions, which is the first-line treatment for pregnant smokers. Current U.S. clinical recommendations for prenatal smoking cessation do not address postcessation weight gain.[21] In a 2013 Cochrane Review of psychosocial interventions for smoking cessation, two RCTs addressed weight gain.[15] One examined differences between intervention and control groups at the eighth month of pregnancy, finding a significant 1.0 kg (2.2 pounds) greater gain in the treatment group.[8] A smaller RCT found a 2.8 kg (6.2 pounds) unadjusted increase in weight gain among biochemically confirmed quitters compared to smokers, which is similar to our findings.[7] Although this difference was no longer significant after adjustment for confounders, the authors did not adjust for gestational age at delivery. We found only one other RCT not included in the Cochrane Review which estimated that biochemically confirmed quitters would gain 5.0 kg (11.0 pounds) more than continuing smokers of similar BMI, parity, and gestational age at delivery.[22] This is greater than the difference we found at delivery, possibly due to differences in the distribution of obstetrical and other factors in the two study populations.

None of the previous RCTs examined weight gain according to IOM recommendations. Recent estimates indicate 48% of the U.S. population of women giving birth gain excessive weight during pregnancy.[23] We found that a high percentage of continuing smokers (46.3%) and quitters (60.3%) gained above current recommendations. Further, a higher proportion of continuing smokers gained weight below recommendations and only about one third of quitters and continuing smokers gained within recommendations, indicating a general need for weight management to achieve optimal weights during pregnancy.

Several components of weight control programs for non-pregnant women, including calorie goals, structured meal plans, behavioral therapy, and ongoing contact with practitioner, have been shown to be effective for weight management during pregnancy.[24] More research is needed to determine the efficacy of weight management programs in smokers and whether they can facilitate cessation in pregnant smokers. Further, interventions may need to be tailored by parity as multiparous women appear less likely to quit than nulliparous women.[25]

This study uses data from the largest RCT to our knowledge that includes cotinine-validated smoking cessation. Biochemical validation is important because relying on self-report can result in overestimation of smoking cessation and underestimations of smoking intensity. However, this study also has several limitations. First, this secondary analysis may have been underpowered to detect differences in some subanalyses. Second, a high percentage

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of women in the original trial were excluded in this analysis because they were lost to follow-up at 30 weeks' gestation or for other reasons. These women were more likely to be smokers at their last visit, which may bias our results; however, these women were similar to those included in our analysis with respect to race/ethnicity, education, parity, marital status, prepregnancy BMI, state of residence, and smoking status at enrollment. Third, our findings may not be generalizable to all pregnant smokers as our study population was predominantly white women from clinics within three states. Although the prevalence of overweight and obesity has increased since this study was conducted in the early 1990s, trends in gestational weight gain within BMI groups have not changed substantially[14]; recent estimates based on population-based samples are around 31 pounds (14 kg), similar to our study.[26] We relied on self-reported prepregnancy weight, which may not reflect true weight. Studies show that underweight women tend to overestimate prepregnancy weight, whereas normal weight, overweight, and obese women underestimate prepregnancy weight with degree of underestimation increasing with higher BMI.[27,28] Although self-report has been shown to be acceptable when clinical measurements at conception are unobtainable,[29,30] errors in self-reported weight could have biased our calculated gestational weight gain estimates. Given that the overall distribution of BMI was similar between smokers and quitters in our study, we do not believe this bias would be differential for smoking status. Further, weight measurements were collected at 30–34 weeks of gestation, and we did not have clinically measured total gestational weight gain on all women in our main analysis. Data on weight gain closer to the time of delivery were available for a subset of our study population, and our finding that the mean weight gain among quitters was elevated compared to continuing smokers (by nearly 5 pounds or 2.2 kg overall) was similar to findings for women analyzed at 30–34 weeks (3.0 and 6.6 pounds or 1.4 and 3.0 kg) for nulliparous and multiparous women. Finally, we might not have fully adjusted for all confounders as we were unable to assess factors such as nutritional intake and physical activity.

In conclusion, women who quit smoking during pregnancy gained more weight at 30–34 weeks and at term than women who continued to smoke. However, this increase in gestational weight gain was modest, especially in nulliparous women. High percentages of quitters and continuing smokers gained in excess of IOM recommendations. Providers should continue to promote smoking cessation early in pregnancy. More research is needed with respect to the intersection of weight management programs and smoking cessation interventions to determine the efficacy of these programs in smokers and whether weight management programs can increase cessation rates in pregnant smokers.

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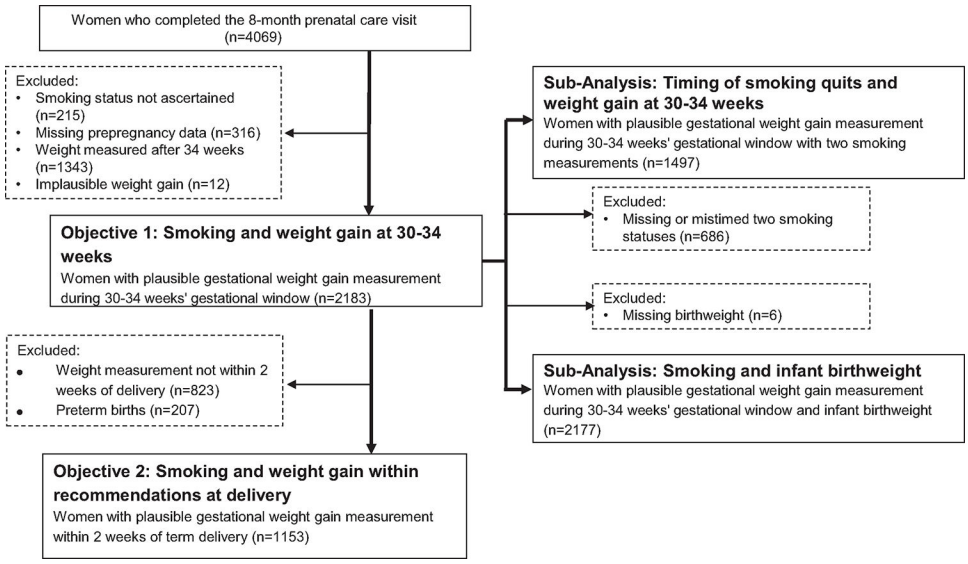

FIGURE 1.

Study Flowchart, secondary analysis of the Smoking Cessation in Pregnancy project, a randomized clinical trial in Colorado, Maryland, and Missouri (1987–1991). Inclusion criteria from the original Smoking Cessation in Pregnancy trial were clinics with ≥15 women enrolled in the RCT and women within eligible clinics who delivered singleton infants and completed the eighth-month visit by 30-wk gestation.

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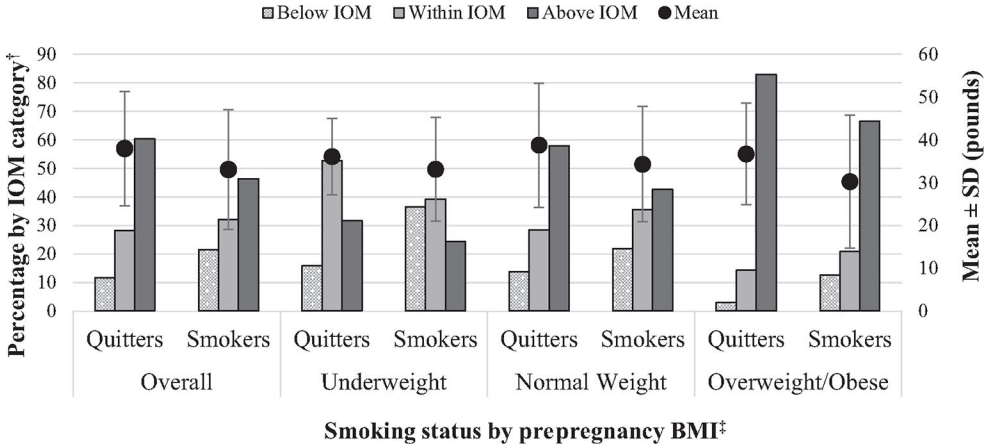

FIGURE 2.

Percentage of women† classified by the 2009 IOM guidelines‡ and mean gestational weight gain by smoking status, Smoking Cessation in Pregnancy project, a randomized clinical trial in Colorado, Maryland, and Missouri (1987–1991). BMI, body mass index; IOM, Institute of Medicine; SD, standard deviation. †Women with a weight measurement within 2 wks of term (≥37 wk) delivery (N = 1153). ‡IOM adequate weight gain recommendations are categorized by maternal prepregnancy BMI: underweight 28–40 pounds, normal weight 25–35 pounds, overweight 15–25 pounds, and obese 11–20 pounds

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Birth. Author manuscript; available in PMC 2024 July 24.

TABLE 1

Maternal and infant characteristics by smoking status, Smoking Cessation in Pregnancy project, a randomized clinical trial in Colorado, Maryland, and Missouri (1987–1991)

	Quitters	Smokers	
Characteristics	**N = 267 N (%) or mean ±SD**	**N = 1917 N (%) or mean +SD**	***P* value[a]**
Maternal age at enrollment, years	21. 6 ± 4.3	23.1 ± 4.7	<0.001
White	193 (72.6)	1485 (77.5)	0.075
Married	106 (39.8)	731 (38.2)	0.60
Enrolled in WIC during pregnancy	178 (66.9)	1318 (68.7)	0.77
Maternal education			
Less than high school	96 (36.2)	795 (41.6)	0.09
High school or more	169 (63.8)	1116 (58.4)	
Parity			
First birth	165 (62.3)	812 (42.4)	<0.001
Second or later birth	100 (37.7)	1103 (57.6)	
Prepregnancy BMI, kg/m^2			
Underweight (<18.5)	32 (12.0)	320 (16.7)	0.21
Normal weight (18.5–24.9)	173 (65.0)	1151 (60.0)	
Overweight (25.0–29.9)	40 (15.0)	273 (14.2)	
Obese (≥30.0)	21 (7.9)	173 (9.0)	
Passive smoke exposure during pregnancy, hours/day			
0	40 (15.1)	103 (5.4)	<0.001
1–8	126 (47.5)	626 (32.9)	
≥8	99 (37.4)	1176 (61.7)	
Self-reported smoking level at enrollment[b], cigarettes/day			
No current smoking (0)	189 (71.6)	117 (6.2)	<0.001
Light smoking (<1–5)	51 (19.3)	497 (26.2)	
Moderate or heavy smoking (≥6)	24 (9.1)	1285 (67.7)	
Reported alcohol use during pregnancy	52 (19.6)	391 (20.6)	0.73
Gestational age at birth by LMP (weeks)	39.6 ± 2.4	39.6 ± 4.6	0.01
State			

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Characteristics	Quitters N = 267 N (%) or mean ±SD	Smokers N = 1917 N (%) or mean +SD	*P* value[a]
Colorado	120 (45.1)	578 (30.2)	<0.001
Maryland	80 (30.1)	650 (33.9)	
Missouri	66 (24.8)	689 (35.9)	

All parameters may not sum to total due to missing data.

BMI, body mass index; LMP, last menstrual period; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children.

[a]Chi-square tests were used for categorical variables, and Wilcoxon-Mann-Whitney tests were used for non-normally distributed continuous variables.

[b]Number of self-reported cigarettes smoked per day in the last 7 days at the time of the enrollment questionnaire.

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TABLE 2

Absolute mean and range of gestational weight gain (pounds) at 30–34 weeks by smoking status stratified by parity, Smoking Cessation in Pregnancy project, a randomized clinical trial in Colorado, Maryland, and Missouri (1987–1991)

Parity and smoking status [a]	N	Gestational weight gain, pounds Mean ± SD	Range	Adjusted mean difference in gestational weight gain (95% CI)
Nulliparous				
Quitters	165	31.0 ± 12.9	1–80	3.0 (0.9–5.1) [b]
Continuing smokers	812	27.8 ± 12.4	−11–92	Reference
Timing of cessation[c]				
Early quitters	59	29.4 ± 15.3	3–80	0.8 (-2.4–4.0)[d]
Late quitters	43	32.8 ± 13.2	1–67	4.2 (0.4–8.0) [d]
Continuing smokers	568	28.6 ± 12.3	−11–92	Reference
Multiparous				
Quitters	100	30.9 ± 11.8	0–78	6.6 (4.3–8.9)[b]
Continuing smokers	1,103	24.5 ± 11.9	−12–80	Reference
Timing of cessation[c]				
Early quitters	39	32.4 ± 11.4	15–71	8.1 (3.4–12.8) [d]
Late quitters	29	31.4 ± 9.8	10–47	6.4 (3.3–9.5) [d]
Continuing smokers	739	24.8 ± 11.6	−12–79	Reference

SD, Standard Deviation; *CI*, 95% Confidence Interval; 1 pound = 0.45 kg.

[a] Quitters: quit by third trimester; Early Quitters: quit by the second trimester and stayed quit through the third trimester; Late Quitters: quit by the third trimester; Continuing smokers: smoking at last trimester.

[b] Adjusted for race, parity, pre-pregnancy body mass index (continuous), gestational age at weight measurement, interaction of parity and smoking status and accounted for clustering by clinic using multivariable linear regression (n = 2,180).

[c] For analysis of timing of cessation (early vs. late), those with incomplete data were excluded.

[d] Adjusted for race, parity, pre-pregnancy body mass index (continuous), gestational age at weight measurement, interaction of parity and smoking status and accounted for clustering by clinic using multivariable linear regression (n = 1,495).