Smoking Status During and After Pregnancy: Associations with Maternal Weight Retention and Concerns about Body Image

Roxanna Belshaw

Submitted in Fulfillment
of the Requirements for the
UC Berkeley Department of Statistics
Honor's Thesis

January 2003

Acknowledgments

I would like to thank both of my advisors, Professor Deborah Nolan with the UC Berkeley Department of Statistics and Professor Barbara Abrams with the UC Berkeley School of Public Health. I am very grateful for the time that both of them spent working with me on this project. I would also like to thank the UC Berkeley Department of Statistics for their generosity with financial assistance for the project.

Contents

Précis

Postpartum smoking is associated with maternal weight retention, history of weight cycling, and some body image concerns. Cessation of smoking during pregnancy and postpartum is also associated with maternal weight retention, though this does not appear to be influenced by body image or a history of weight cycling.

Abstract

Objective: To explore the relationship between postpartum smoking and maternal postpartum weight retention, a history of weight cycling, and concerns about body image. Additionally, to explore the relationship between smoking behavior during pregnancy and postpartum among women who smoked before their pregnancies and maternal postpartum weight retention, a history of weight cycling, and concerns about body image.

Methods: Cross-sectional data from the "After the Baby Comes" study were analyzed using two logistic models. Postpartum smoking was evaluated for 929 women and pregnancy and postpartum smoking behavior was evaluated for 125 women. Twenty percent of the women in the study were active duty service personnel; the other eighty percent were the wives of active duty servicemen. Postpartum weight data was collected on average 7.7 months after birth.

Results: The prevalence of postpartum smoking was 20%. After adjusting for breast feeding practices, maternal height, race, age, active duty status, marital status, parity, income, level of education, and other maternal characteristics, maternal weight retention and history of weight cycling were significantly associated with postpartum smoking. Other predictors included height, black and Asian race, level of education, the baby's birth weight, the participant's weight as a young girl, and breast feeding practices. After adjusting for the same maternal characteristics listed above, maternal weight retention was significantly associated with smoking cessation during pregnancy and remaining so postpartum. Other significant predictors for pregnancy and postpartum smoking habits among prior smokers included the baby's maternal grandmother's usual appearance or figure, Asian race, the baby's birth weight, and level of education.

Introduction

Maternal smoking during pregnancy is a significant issue in the field of public health. Maternal smoking, both during and after pregnancy, has been implicated in many childhood diseases. The effects of smoking on the baby are magnified if the mother continues to smoke around the child during the early postpartum period.[1] Many women cease smoking during pregnancy, but at one year postpartum, relapse rates are estimated to be between 50 and 80 percent.[2] This represents a significant number of children who are being exposed to a hazardous toxin early in their life. Many women cease or reduce their amount of smoking during pregnancy, but the majority of these women will relapse.[3,4,5] Therefore, it is important to further our knowledge of risk factors in order to better predict which women are at an elevated risk for postpartum smoking and relapse.

Numerous studies have identified predictors of smoking during pregnancy, but considerably less is known about smoking during the postpartum period. Studies of postpartum smoking have produced inconsistent findings. However, living with a partner who smokes has been consistently shown to be a predictor of postpartum relapse.[6,7,8,9,10] Additional studies show that women who smoke postpartum initiate breast feeding at lower rates than non-smokers.[3,11,12,13,14]

New motherhood is a time of great personal change. Not all of these changes are positive, with new mothers often faced with depression, stress, poor social support, weight changes, and struggles with body image. Any of these changes could potentially lead to postpartum smoking, though they have not been adequately studied.

The relationship between weight change and smoking is particularly complicated. Many women smoke to maintain or lose weight.[15,16,17] Therefore, a woman who smokes

to maintain her weight is likely to be unsatisfied with her pregnancy weight gain and postpartum weight retention. This could potentially lead to postpartum smoking. Additionally, women who stop smoking during pregnancy gain more weight than women who smoke throughout their pregnancies and non-smokers.[18] Pregnancy weight gain is highly correlated with postpartum weight retention.[19] Therefore, women who cease smoking during pregnancy are at high risk for retaining weight postpartum if they remain nonsmokers.[20] This may lead to an eventual smoking relapse.

Some studies have found relationships between weight concern, or body image, and smoking relapse.[21,22] Weight cycling, defined as a repeated loss and regain of body weight, is one measure of weight concern. Additional measures of weight or body image concern include self-reported worry about weight, shape, and appearance and self-reported weight perception.

This study explores the relationship between postpartum smoking during the first year postpartum and various maternal characteristics including postpartum weight retention, history of weight cycling, prepregnancy weight perception, and various other measures of body image concern. Specifically, this study attempts to identify if (1) postpartum weight retention, (2) a history of weight cycling, or (3) body image concerns are predictive of postpartum smoking. Additionally, this study attempts to determine if these same risk factors can predict smoking cessation during pregnancy or postpartum relapse among women who reported smoking at the beginning of their pregnancy.

Logistic Regression[23]

Introduction

Regression models are helpful for numerous applications in many different fields. These models serve to evaluate the relationship between one or more independent, or predictor, variables and a dependent, our outcome, variable. These models are particularly useful due to the ability to make predictions from the model and due to the results showing a clear, easy to understand relationship between the predictors and the outcome being studied. There are two main categories for regression models: linear and logistic. In the first case, the outcome being studied is in the continuous spectrum; in the latter the outcome being studied is a discrete variable, usually binary or dichotomous, though this model can be extended for the case of a polytomous discrete outcome variable.

A multiple logistic regression model describes the relationship between several predictor variables and a binary outcome. This is useful, for example, when studying predictors of smoking. Smoking is a binary outcome, since a person either smokes or they do not smoke. In a model looking at predictors of smoking, the outcome variable, *Y=1/Y=0* for yes/no, is smoking and the various predictor variables are denoted $x_1, x_2, \ldots, x_p$. When using the logistic model, we assume that the predictor values $x_1, x_2, \ldots, x_p$ determine the probability of *Y=1*. This probability is denoted $P(Y = 1 \mid x_1, x_2, \ldots, x_p) = \pi(\underset{\sim}{x})$. This probability is then modeled on what is called a logit scale as a linear function of the predictor variables. This is represented as:

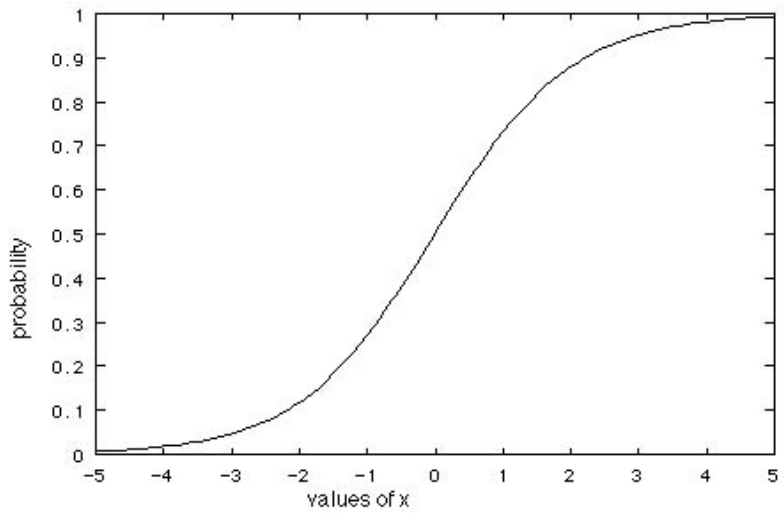
$$\text{logit}\,\pi(\underset{\sim}{x}) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p$$

The logit scale is defined as $\text{logit}(\underset{\sim}{x}) = \ln \frac{\pi(\underset{\sim}{x})}{1-(\underset{\sim}{x})}$. Therefore, solving for $\pi(\underset{\sim}{x})$ gives:

$$\pi(\underset{\sim}{x}) = \frac{e^{\beta_0+\beta_1 x_1+\ldots+\beta_p x_p}}{1+e^{\beta_0+\beta_1 x_1+\ldots+\beta_p x_p}}.$$

The coefficients $\beta_0, \beta_1, \ldots \beta_p$ are the unknown regression coefficients, which are being estimated from the data. The logit transformation above is beneficial in many ways. It is similar to a linear regression model since $\text{logit}(\underset{\sim}{x})$ has linear parameters and may be continuous. This transformation is bounded between 0 and 1 and represented by the logistic curve as shown in Figure 1 below.

Figure 1: *A graphical representation of the logit transformation*[24].



In the linear regression model, the outcome variable is expressed as the expected value plus error, represented as $y = E(Y \mid x) + \varepsilon$, where ε is the error. In the linear regression model, this error is assumed normally distributed with mean 0 and some constant variance. However, this is not the case for the logistic regression model. Here,

$$y = P(Y = 1 \mid x_1, x_2, \ldots, x_p) + \varepsilon .$$

Since y is a binary variable, y may only take on the values 0 and 1. If y = 1, then $\varepsilon = 1 - P(Y = 1 \mid x_1, x_2, \ldots, x_p)$ with probability $P(Y = 1 \mid x_1, x_2, \ldots, x_p)$. If y = 0, then $\varepsilon = - P(Y = 1 \mid x_1, x_2, \ldots, x_p)$ with probability $1 - P(Y = 1 \mid x_1, x_2, \ldots, x_p)$. Therefore, ε has a binomial distribution with mean 0 and variance equal to:

$$P(Y = 1 \mid x_1, x_2, \ldots, x_p)[1 - P(Y = 1 \mid x_1, x_2, \ldots, x_p)].$$

Fitting the Logistic Regression Model

Fitting the logistic regression model involves using the method of maximum likelihood. This method involves maximizing the likelihood function, which is a function that expresses the probability of the observed data as a function of the predictor variables. Using smoking as the outcome of interest, a smoker equals an outcome of 1 and a nonsmoker equals an outcome of 0. As mentioned previously, the probability that Y=1 given $x_1, x_2, \ldots, x_p$ equals $\pi(\underset{\sim}{x})$, and $P(Y = 0 \mid x_1, x_2, \ldots x_p) = 1 - \pi(\underset{\sim}{x})$. Thus, when a person is a smoker, their individual contribution to the likelihood function is $\pi(\underset{\sim}{x_i})$. When a person is a nonsmoker, their individual contribution to the likelihood function is $1 - \pi(\underset{\sim}{x_i})$. Thus, an expression for any individual's contribution to the likelihood function is given by:

$$f_{\pi(\underset{\sim}{x})}(\underset{\sim}{x_i}) = \pi(\underset{\sim}{x_i})^{y_i}[1 - \pi(\underset{\sim}{x_i})]^{y_i}$$

The likelihood function is the product of these individual contributions and is expressed below:

$$l(\underset{\sim}{\beta}) = \prod_{i=1}^{n} f_{\pi(\underset{\sim}{x})}(\underset{\sim}{x_i})$$

Maximizing the likelihood function gives several resulting likelihood equations:

$$\sum_{i=1}^{n}[y_i - \pi(\underset{\sim}{x_i})] = 0 \text{ and } \sum_{i=1}^{n} x_{ij}[y_i - \pi(\underset{\sim}{x_i})] = 0$$

for $j = 1,2,\ldots, p$.

The likelihood equations can be solved using software found in most statistical software packages.

Interpretation of the Coefficients

The coefficients of the logistic regression model can be expressed in one of two ways. They can be expressed as the coefficients given from the solution of the likelihood equations or they can be expressed as odds ratios (OR).

The estimated coefficients from the solutions to the likelihood equations are measured on the logit scale. In general, if $\beta_j > 0$ then as x_j increases, $\pi(\underset{\sim}{x})$ also increases. If $\beta_j = 0$, then the predictor variable has no effect on the outcome. If $\beta_j < 0$ then as x_j increases, $\pi(\underset{\sim}{x})$ decreases. However, the actually magnitude of the relative change can not be measured directly from the coefficients since they are measured on the logit scale. To see the magnitude of these relative changes, the coefficient needs to be converted to the ordinary scale. For example, suppose the logistic regression model looking only at postpartum smoking and education level is given below:

$$\text{logit}\, P(Y = 1 \mid \textit{education}) = .13 - 0.50 * \textit{education}$$

At the high school education level, the predicted probability of smoking given only a high school education (coded as education=2) is -.87 on the logit scale. To get a better

understanding of this relationship, we need to convert to the ordinary scale as shown below:

$$\pi(x) = P(Y = 1 \mid education = 2) = \frac{e^{-0.87}}{1 + e^{-0.87}} = .30$$

From this we see that the probability of smoking postpartum given only a high school education is approximately 30%. Of course this is a highly simplified example with no adjustments being made for other variables.

The logistic regression model can also be looked at in terms of odds ratios. This method has some practical applications for studies since it is an easy way to understand the relationship between the predictors and the outcome being studied. Suppose the same model described above estimates the odds ratio for smoking given educational background at 0.61. This means that postpartum smokers are at 0.61 times increased odds or, equivalently and more understandably, 1/0.61=1.64 times decreased odds of having more years of education than postpartum nonsmokers without considering any other variables.

Now suppose we are interested in comparing the odds of postpartum smoking given difference ethnic groups without considering any other variables in the model. Since in this case the predictor variable is polytomous (white, black, Asian, Hispanic, and other), we cannot just include the race variable in the model. In this case, race needs to be broken into dummy variables. However, these dummy variables are not linearly independent in the logistic regression model since it also includes a constant. Therefore, one of the race dummy variables needs to be excluded. After excluding one of these dummy variables, all of the remaining odds ratios need to be interpreted relative to the excluded variable. The dropped race will serve as the reference group. For example,

supposed we exclude the white race variable from the model and the remaining odds ratios are 0.39 for black, 0.26 for Asian, and .59 for Hispanic. Interpretation of these odds ratios is as follows. Postpartum smokers are at 1/0.39 = 2.56 times decreased odds of being black than white, 3.85 times decreased odds of being Asian than white, and 1.69 times decreased odds of being Hispanic than white compared to postpartum nonsmokers.

Multinomial Logistic Regression Model

Multinomial logistic regression differs from standard logistic regression since the outcome variable is non-binary and discrete. In this case, there are three or more categories for which predictions need to be made. However, the methods for fitting the model and interpreting the results are very similar to logistic regression with a binary outcome. For example, an outcome variable with three categories will produce two binary logistic regression equations. One category is designated as a reference category, and the additional two categories are compared to the reference category. In other words, the multinomial logistic regression model will compute two different binary logistic regression equations using each of the two additional categories as the outcome of interest for the separate equation compared to the designated reference category. In fact, for any categorical outcome variable with *k* categories, the multinomial logistic regression model will produce *k*-1 binary logistic regression equations.

Again, let us consider using race as a predictor variable. In this case, however, the outcome variable will have categories: smoking during pregnancy, quitting smoking during pregnancy and relapsing postpartum, and quitting smoking during pregnancy and remaining a nonsmoker postpartum. Designating the pregnancy smokers as the reference group, suppose we get the following significant associations:

Postpartum Relapsers		*Pregnancy Quitters*	
	OR		OR
Black	1.45	Asian	4.7
Asian	2.1		
Hispanic	2.5		

Interpretation of the results for this hypothetical situation is as follows. Women who ceased smoking during their pregnancy but relapsed postpartum were at 1.45 times increased odds for being black, 2.1 increased odds from being Asian, and 2.5 times increased odds for being Hispanic when compared to women who smoked throughout their pregnancy and postpartum. Women who ceased smoking during their pregnancy and remained nonsmokers postpartum were at 4.7 times increased odds for being Asian when compared to women who smoked throughout their entire pregnancy and postpartum.

What if we are interested in using race as a predictor of quitting smoking during pregnancy and remaining a nonsmoker postpartum compared to women who ceased smoking during their pregnancy but relapsed postpartum? In this case, the reference group needs to be designated as postpartum relapsers. Suppose the following relationship is found:

Pregnancy Quitters	
	OR
Asian	1.9

Interpretation in of these hypothetical results is as follows. Women who quit smoking during pregnancy and do not relapse postpartum are at 1.9 times increased odds for being Asian when compared to women who ceased smoking during pregnancy but relapsed postpartum.

Methods

Data

The "After the Baby Comes" study (ABC Study) was conducted at the Balboa Pediatrics Clinic at the Naval Medical Center in San Diego. The study was originally designed to observe maternal weight loss during the first year postpartum, compare differences in weight loss to maternal characteristics, and to identify risk factors for women likely to become overweight as a result of pregnancy. All women enrolled in this study were either active duty military personnel or wives of active duty personnel. 7,723 women received well baby care at the Balboa Pediatric Clinics between April 1997 and December 1999, 4,321 women were screened, and 2,812 were eligible for and enrolled in the study. Eligibility requirements for participants included having delivered an infant at most 12 months prior to enrollment, being a fluent English speaker, having their infant spend no more than 96 hours in the neonatal intensive care unit, not being pregnant at the time of enrollment, and intention to continue well baby care beyond the 10-16 day visits. Though the original outcome variables for this study were maternal prenatal and postpartum weight change, data were collected regarding smoking practices during and after pregnancy.

The data for this study were collected through questionnaires over a period of approximately two years. For the analysis in this study, data from two questionnaires were used: (1) a baseline questionnaire, filled out by the woman once at the time of enrollment in the study, which contained the smoking data and other various maternal characteristics and (2) the participant's latest completed clinic questionnaire, completed no earlier than two months and no later than 18 months postpartum, which contained the

postpartum weight data. Complete smoking data were available for 1728 women; however, the study sample for prediction of postpartum smoking was limited to women with complete data on the variables used for the analysis (n=929). Data for women who smoked throughout their pregnancies, women who ceased smoking during their pregnancy and did not relapse postpartum, and women who quit smoking during their pregnancy but relapsed postpartum were available for 228 women. This sample was further limited to women with complete data on the variables used for the analysis (n=125).

Questionnaires and Measures

Women were classified as postpartum smokers or postpartum nonsmokers based on whether they reported smoking at any time in the postpartum period on either the baseline questionnaire or any of the clinic questionnaires. This was evaluated by their answer to whether or not they smoked any cigarettes within the past thirty days.

Women were classified as pregnancy smokers, pregnancy quitters, or pregnancy relapsers based on their answers to several smoking questions. All women in these categories reported smoking at the beginning of their pregnancy. Women who were classified as pregnancy smokers reported smoking during the 3rd trimester and also reported smoking postpartum (n=49). Women who were classified as pregnancy quitters reported no smoking by the third trimester and also did not report any postpartum smoking on the baseline questionnaire or on any of their clinic questionnaires (n=35). Women who were classified as pregnancy relapsers reported no smoking by the third trimester but reported smoking postpartum (n=41).

This study looked at predictors of postpartum smoking regardless of smoking habits before and during pregnancy in one model and, additionally, looked at comparative predictors of smoking throughout pregnancy, quitting smoking during pregnancy, and relapsing postpartum.

Predictor Variables

Time was reported in days since the birth of the infant until the latest clinic questionnaire date in order to adjust the maternal postpartum weight for time. Maternal age was reported in years. Parity was included in the model and ranged from 0-5. Active duty status was self-reported (Y/N) as was whether or not the woman was married or living with a partner. Additional definitions of maternal characteristics/predictor variables are summarized in Table 1.

Concern about body image in terms of worry about weight, shape, appearance, and food, prepregnancy weight perception, and weight as a young girl was evaluated using a four-point scale. A four-point scale was also used to measure the participants' mother's usual figure (sculptural appearance). The woman's desire to gain or lose weight was assessed on a four-point scale by evaluating the difference between the woman's current self-reported figure and her desired figure. These figures were assessed using the Silhouette Technique[25]. History of weight cycling was coded as Y/N and is defined as losing at least ten pounds and gaining it all back at least 3 times in the woman's lifetime. Postpartum weight retention was calculated by subtracting the maternal postpartum weight at the time of the latest clinic questionnaire from the reported prepregnancy weight.

Analysis

Statistical analyses were conducted using STATA 7.0 statistical software.[26] Individual distributions and correlations were examined for independent variables and postpartum smoking/non-smoking and for pregnancy smoking, pregnancy quitting, and postpartum relapsing. Multiple logistic regression was performed using postpartum smoking as the outcome of interest. Multinomial logistic regression (m-logit) models were used for the three categories of pregnancy smoking, pregnancy quitting, and postpartum relapsing. This allows for direct comparison of the three groups using odds ratios with one group designated as a reference group.

Since the variables "worry about weight/shape/weight/food" are highly correlated they were not included in either of the regression models simultaneously. Two different methods were used to address this. First, each variable was put into the models separately. Results for each of the four variables were nearly identical. In the second method, the average of the four variables was taken after converting the values to a z-score to standardize the variance. This average was put into the model. Results were similar to the first method; therefore, only the results of the latter method are presented here.

Results

Tables 2, 3, 4, and 5 show that the two analyzed study populations did not differ substantially from the two total study populations. Baseline questionnaires were completed on average 136 days (4.5 months) postpartum. The latest clinic questionnaires were completed on average 236 days (7.7 months) postpartum for the postpartum smoking model and 233 days (7.7 months) postpartum for the m-logit smoker model. The

postpartum smoking study population was racially diverse; however, the trichotomized smoking population was predominantly white. Both study populations had a high proportion of women who attended at least some college, although the trichotomized smoking population had a lower proportion of college educated women than the postpartum smoking study population. Nearly all of the women in both populations were married or living with a partner.

Postpartum smoking rates were estimated at 20% for the postpartum smoking study population. In the trichotomized smoking population, 39% of smokers smoked throughout their pregnancy, 33% of smokers ceased smoking during pregnancy but relapsed postpartum, and 28% of smokers ceased smoking during pregnancy and remained nonsmokers at on average 233 days postpartum. Of this population, 61% of all smokers stopped smoking during their pregnancy, but 54% of these women returned to smoking by, on average, 233 days postpartum.

Results of the full logistic regression model with postpartum smoking as the outcome are shown in Table 6. After adjustment for the covariates included in the model, postpartum weight retention, a history of weight cycling, worry about weight, weight as a young girl, and feeding a baby only formula were significant predictors. Additionally, increased height, black and Asian race, education, and baby's birth weight were significant in the model.

Results of the m-logit analysis with trichotomized smoking categories as the outcome are shown in Table 7. Postpartum relapsers were at 1.46 times increased odds for having an overweight mother than women who smoked throughout their pregnancy. Pregnancy quitters were at 1.14 times increased odds for retaining more weight

postpartum and were at slightly increased odds for having a heavier baby at birth compared to women who smoked throughout their pregnancy. Pregnancy quitters were also at 38.21 times increased odds for being Asian than white and were at 2.43 times increased odds for having more education than women who smoked throughout their pregnancy. Pregnancy quitters were also at 1.86 times increased odds for having more education than women who ceased smoking during pregnancy but relapsed postpartum.

Discussion

This study was conducted in a military population, though the results seem comparable to the general population of postpartum women. Results of a study of cigarette smoking in the military population conformed to past studies that indicate higher smoking rates among military personnel than among civilians.[27] However, this does not seem to be generalizable to the pregnancy quit rates for the women in this study population. A larger number of women in this study population ceased smoking during pregnancy (61%) than the estimated 20-40% for the general population from previous studies[3,4,6]. The postpartum relapse rate of 54% is within the estimated range of 50-80% for the general population.[2]

The hypothesis that women who retain more weight postpartum are at higher risk for smoking cannot be supported by this study. Women who smoked postpartum were at 1.03 times decreased odds for retaining more weight postpartum than women who did not smoke postpartum. However, this study was cross-sectional and, therefore, causality cannot be determined. Since some women cite smoking as a form of weight control,[15,16,17] it is likely that women who smoked postpartum retained less pregnancy weight due to

smoking. However, women who smoked postpartum were more likely to have a history of weight cycling and to have been overweight as a young girl. This supports the hypothesis that women who smoke postpartum are more likely to have concerns about body image than women who do not smoke postpartum.

Additionally, the results from the postpartum smoking model agree with certain predictors of smoking during pregnancy. This is likely do to the high correlation between smoking during pregnancy and postpartum smoking. These women are less like to be black or Asian than white,[28,29,30,31] are less educated,[3,6,32,33] and have lower birth weight babies.[34] Results of this study also show that postpartum smokers are at 1.96 times decreased odds for feeling formula only than breast milk only when compared to postpartum nonsmokers. This contradicts previous studies that have found postpartum smokers initiating breast feeding at lower rates than non-smokers.[3,11,12,13,14]

No differences in body image issues or weight cycling were found between women who smoked throughout their pregnancies, women who ceased and did not relapse, and women who quit but relapsed postpartum. However, pregnancy quitters were more likely to retain more weight than women who smoked during and after their pregnancies. This is likely due to the fact that women gain weight when they ceased smoking.[35]

Results of prior studies of postpartum relapse have had contradicting results. The results of this study show that women who ceased smoking during pregnancy and do not relapse are at increased odds for being Asian than white, more educated, and are at slightly increased odds for having a higher birth weight baby than women who smoke throughout their pregnancy. Women who quit smoking during pregnancy and do not

relapse postpartum are more likely to be more educated than women who quit smoking during pregnancy but relapse postpartum. This study found no association between postpartum smoking relapse and maternal age[36,37] or parity,[37,38] as have other studies. Previous studies have consistently shown no association between socioeconomic status and postpartum smoking relapse. This study did not differ from previous studies in this aspect.

Because the ABC study was designed to study postpartum weight retention, not all information that would be relevant to postpartum smoking status was collected. Studies of postpartum smoking have shown that living with a partner who smokes will consistently predict relapse. These data were not available for this study. Other smoking data that would have been of interest for this study would include the length of time a woman smoked prior to her pregnancy and more detailed information regarding her smoking habits immediately prior to her pregnancy.

Additionally, the m-logit model in this study was limited by its small numbers and due to the sample being disproportionately white. Therefore, associations that exist in some ethnic groups may not have been apparent due to the limited power of this model. Although a significant association was found in the Asian race, the large range of the 95% confidence interval demonstrates the need for additional power to get more precise results not only in the Asian race, but among the other ethnic groups as well.

In summary, this study shows that body image concerns and postpartum weight retention may be linked to postpartum smoking. Additionally, increased postpartum weight retention may be linked to quitting smoking during pregnancy and remaining a nonsmoker postpartum. Additionally, this study consistently shows that postpartum

smokers as less likely to be as highly educated as postpartum nonsmokers, and that women who quit smoking during pregnancy but do not relapse postpartum are more likely to be more educated than women who smoke throughout their pregnancies and women who quit smoking during their pregnancies but relapse postpartum.

1. DiClemente CC, Dolan-Mullen P, Windsor RA. The process of pregnancy smoking cessation: implications for interventions. *Tobacco Control* 2000; 9 Suppl 3 III:16-21.
2. Ockene J. Smoking among women across the life span: prevalence, interventions, and implications for cessation research. Ann Behav Med 1993;15:135-4.
3. O'Campo P, Faden RR, Brown K, Gielen AC. The impact of pregnancy on women's prenatal and postpartum smoking behavior. Am J Prev Med. 1992;8:8-13.
4. Hickner J, Westenberg C, Dittenbir M. Effect of pregnancy on smoking behavior: A baseline study. J Fam Practice. 1984;18:241-244.
5. Stewart PJ, Dunkley GC. Smoking and health care patterns among pregnant women. CMAJ. 1985;133:989-94.
6. Severson HH, Andrews JA, Lichtenstein E, Wall M. Predictors of smoking during and after pregnancy; a survey of mothers of newborns. *Preventative Medicine*. 1995; 24:23-28.
7. Wakefield M, Gillies P, Graham H, Madeley R. Characteristics associated with smoking cessation during pregnancy among working class women. *Addiction*. 1993;88:1423-30.
8. McBride CM, Pirie PL, Curry SJ. Postpartum relapse to smoking: a prospective study. *Health Education Research.* 1992;7:381-390.
9. Mullen PD, Richardson MA, Quinn VP, Ershoff SH. Postpartum return to smoking: who is at risk and when. *American Journal of Health Promotion*. 1997;11:323-330.
10. Severson HH, Andrews JA, Lichtenstein E, Wall M, Akers L. Reducing maternal smoking and relapse: long-term evaluation of a pediatric intervention. Preventative Medicine 1997;26:120-30.
11. Edwards N, Sims-Jones N, Breithaupt K. Smoking in pregnancy and postpartum: relationship to mothers' choices concerning infant nutrition. *Canadian Journal of Nursing Research.* 1998;30:83-98.
12. Eriksen W. Breastfeeding, smoking, and the presence of the child's father in the household. *Acta Paediatr.* 1996;85:1272-1277.
13. Little RE, Lambert MD, Worthington-Roberts B. Drinking and smoking at 3 months postpartum by lactation history. *Paediatr Perinal Epidemiol.* 1990;4:290-302.
14. Clements MS, Mitchell EA, Wright SP, Esmail A, Jones DR, Ford RP. Influences of breastfeeding in southeast England. *Acta Paediatr.* 1997;86:51-56.
15. Brandon TH, Baker TB. The Smoking Consequences Questionnaire: The subjective expected utility of smoking in college students. *Psychological Assessment.* 1991;3:484-491.
16. Camp DE, Klesges RC, Reylea G. The relationship between body weight concerns and adolescent smoking. *Health Psychology.* 1993;12:24-32.
17. Milligan RA, Burke V, Beilin LJ, Richards J. Health-related behaviours and psycho-social characteristics of 18-year old Australians. *Social Science & Medicine.* 1997;45:1549-62.
18. Groff JY, Mullen PD, Mongoven M, Burau K. Prenatal weight gain patterns and infant birth weight associated with maternal smoking. *Birth*. 1997;24:234-239.
19. Parker JD, Abrams B. Differences in postpartum weight retention between Black and while mothers. *Obstet Gynecol.* 1993;81:768-774.
20. Ohlin A, Rossner S. Maternal body weight development after pregnancy. *International Journal of Obesity.* 1990;14:159-173.

21. Streater JA, Sargent RG, Ward DS. A study of factors associated with weight change in women who attempt smoking cessations. *Addictive Behaviors.* 1989;14:523-530.
22. Meyers AW, Klesges RC, Winders SE, Ward KD, Peterson BA, Eck LH. Are weight concerns predictive of smoking cessation? A prospective analysis. *Journal of Consulting and Clinical Psychology.* 1997;54:448-452.
23. Hosmer DW, Lemeshow S. *Applied Logistic Regression.* Wiley-Interscience Publications. 1989. New York.
24. http://www.geocities.com/eva33.geo/logistic.html. Accessed 01/13/03.
25. Stunkard AJ, Sorenson T, Schulsinger F. Use of the Danish Adoption Register for the study of obesity and thinness. *Genetics of Neuro Psychiatr.* 1983;115-120.
26. Stata,C., *Stata 7 User Guide.* 2001, College Station: Stata Press.
27. Feigelman, W. Cigarette Smoking Among Former Military Service Personnel. A Neglected Social Issue. *Preventive Medicine.* 1994;23:235-241.
28. King G, Barry L, Carter DL. Smoking prevalence among prenatal women: the role of socioeconomic status, race, and ethnicity. *Conn Med.* 1993;57:721-728.
29. Ruggiero L, de Groot M. Smoking patterns of low-income ethnoculturally diverse pregnant women: are we casting the net wide enough? *Addictive Behavior.* 1998;23:549-554.
30. Sergent JB, Sheahan SL, Latimer M. Demographic predictors of smoking at initiation of antenatal care. *Journal of the American Academy of Nurse Practitioners.* 1994;6:573-589.
31. Matthews TJ. Smoking during pregnancy, 1990-96. Nation Vital Statistics Report. 1998;47:1-12.
32. Fingerhut LA, Kleinman JC, Kendrick JS. Smoking before, during, and after pregnancy. *American Journal of Public Health.* 1990;80:541-544.
33. Conner SK, McIntyre L. The sociodemographic predictors of smoking cessation among pregnant women in Canada. *Can J Public Health.* 1999;90:352-355.
34. Mitchell EA, Thompson JM, Robinson E, Wild CJ, Becroft DM, Clark PM, Glavish N, Pattison NS, Pryor JE. Smoking, nicotine and tar and risk of small for gestational age babies. *Acta Paediatr*. 2002;91(3):323-8.
35. Williamson DF, Madans J, Anda RF, Kleinman JC. Smoking cessation and severity of weight gain in a national cohort. *New England Journal of Medicine*. 1991;324:739-745.
36. Dalaker K, Grunfeld B, Jansen A. Some social background variables among smoking and non-smoking primiparae. *Scan J Soc Med.* 1983;11:23-26.
37. Dodds L. Prevalence of smoking among pregnant women in Nova Scotia from 1988-1992. *CMAJ*. 1995;152:185-190.
38. Stockbauer JW, Land GH. Changes in characteristics of women who smoked during pregnancy: Missouri, 1978-88. *Public Health Rep.* 1991;106:52-58.

Table 1: Summary of Variables Used in all Statistical Models

Variable Name	Definition
Race	
White	Self-reported white only
Black	Self-reported black or any mixture of black and other/white
Asian	Self-reported Asian or any mixture of Asian and other/white
Hispanic	Self-reported Hispanic or any mixture of Hispanic and other/white
Other	Self-reported any race not listed above
Income	1=$500/month or less 2=$501-1000/month 3=$1001-1500/month 4=$1501-2000/month 5=$2001-2500/month 6=$2501-3000/month 7=$3001-6250/month 8=More than $6250/month
Education	1=Less than high school 2=High school or equivalent 3=Trade or vocational school 4=College 5=Graduate school
History of Weight Cycling	Y/N; = losing and regaining 10 or more pounds intentionally 3 or more times during the woman's lifetime
Prepregnancy Weight Perception/Weight as a young girl	"(At your weight before you got pregnant with this baby/When you were a little girl), did you think you were:" 1=Underweight 2=Just about the right weight 3=A little overweight 4=Very overweight
Body Image Concerns: Worry about weight, shape, food, and appearance	"During the past 7 days, how often did you worry about your (weight/shape/food/appearance)?" 1=Rarely or none of the time 2=Some of the time 3=More than half of the time but not most of the time 4=Most of all of the time
Maternal Grandmother's Usual Figure	"You biological mother usually looks(looked) like:" 1-9: Silhouette Technique

Desire to gain/lose weight	Using the Silhouette Technique (difference between current silhouette and desired silhouette); The woman: 1=Wants to gain weight (negative value) 2=Wants to stay the same weight (0) 3=Wants to lose a little weight (1,2) 4=Wants to lose a lot of weight (3,4,5,6)
Breast feeding practices	1=Feed only breast milk 2=Feed mostly breast milk 3=Feed half breast milk/half formula 4=Feed mostly formula 5=Feed only formula

Table 2: Comparing Maternal Characteristics between the Total Eligible Sample (N=1728) and the Sample with Complete Data used for the Logistic Postpartum Smoking Model (N=929)

Maternal Characteristics	**Total Eligible N=1728**	**Model N=929**
Time, days (mean ± sd)	253.3 ± 106.4	236.4 ± 103.3
Parity, n (%)		
Primiparous	747 (46.4)	449 (48.3)
Multiparous	864 (53.6)	480 (51.7)
Race, n (%)		
White	961 (55.6)	523 (56.3)
Black	242 (14.0)	113 (12.2)
Asian	217 (12.6)	126 (13.6)
Hispanic	270 (15.6)	151 (16.2)
Other	38 (2.2)	16 (1.7)
Education, n (%)		
Did not complete H.S.	90 (5.2)	29 (3.1)
Completed H.S./ GED	549 (31.9)	294 (31.6)
Vocational or trade school	131 (7.6)	68 (7.3)
College	833 (48.4)	461 (49.6)
Graduate School	120 (7.0)	77 (8.3)
Income, n (%)		
$0-500/mo.	16 (1.0)	4 (0.4)
$501-100/mo.	98 (5.8)	53 (5.7)
$1001-1500/mo.	279 (16.5)	132 (14.2)
$1501-2000/mo.	373 (22.0)	200 (21.5)
$2001-2500/mo.	309 (18.2)	166 (17.9)
$2501-3000/mo.	229 (13.5)	127 (13.7)
$3001-6250/mo.	341 (20.1)	215 (23.1)
>$6250/mo.	48 (2.8)	32 (3.4)
Married/living with partner, n (%)		
Yes	1622 (93.9)	872 (93.9)
No	106 (6.1)	57 (6.1)
Active Duty		
Yes	335 (19.4)	194 (20.9)
No	1393 (80.61)	735 (79.1)
Maternal Height, cm (mean ± sd)	162.1 ± 7.0	162.2 ± 7.0
Maternal Age, years (mean ± sd)	25.8 ± 5.4	26.2 ± 5.3
Baby's birth weight, g (mean ± sd)	3423.5 ± 520.3	3428.6 ± 525.6

Table 3: Comparing Outcome Variables between the Total Eligible Sample (N=1728) and the Sample with Complete Data used for the Logistic Postpartum Smoking Model (N=929)

Outcome Variables	**Total Eligible N=1728**	**Model N=929**
Maternal Weight Retention, kg (mean ± sd)	4.9 ± 7.9	5.3 ± 8.4
Weight Cycler, n (%)		
Yes	533 (30.8)	284 (30.6)
No	1195 (69.2)	645 (69.4)
Prepregnancy weight perception, n (%)		
Underweight	93 (5.4)	45 (4.8)
About the right weight	760 (44.2)	406 (43.7)
A little overweight	648 (37.6)	356 (38.3)
Very overweight	220 (12.8)	122 (13.1)
Worried about shape during last week, n (%)		
None/rarely	326 (22.0)	201 (21.6)
Sometimes	659 (44.4)	429 (46.2)
More than half, but not most	293 (19.8)	177 (19.0)
Most or all of the time	205 (13.8)	122 (13.1)
Worried about food during last week, n (%)		
None/rarely	530 (35.8)	328 (35.3)
Sometimes	561 (37.8)	354 (38.1)
More than half, but not most	231 (15.6)	145 (15.6)
Most or all of the time	160 (10.8)	102 (11.0)
Worried about appearance during last week, n (%)		
None/rarely	307 (20.5)	185 (19.9)
Sometimes	688 (46.0)	444 (47.8)
More than half, but not most	320 (21.4)	198 (21.3)
Most or all of the time	182 (12.2)	102 (11.0)
Worried about weight during last week, n (%)		
None/rarely	425 (28.6)	256 (27.6)
Sometimes	588 (39.6)	392 (42.2)
More than half, but not most	264 (17.8)	159 (17.1)
Most or all of the time	207 (14.0)	122 (13.1)
Desire to gain/lose weight, n (%)		
Want to gain weight	63 (3.8)	33 (3.6)
Want to stay the same weight	211 (12.7)	109 (11.7)
Want to lose a little weight	1252 (75.3)	704 (75.8)
Want to lose a lot of weight	137 (8.2)	83 (8.9)

Weight as a little girl, n (%)		
Underweight	63 (3.8)	183 (19.7)
Just about the right weight	211 (12.7)	620 (66.7)
A little overweight	1252 (75.3)	118 (12.7)
Very overweight	137 (8.2)	8 (8.6)
Grandmother's usual figure		
Underweight	181 (11.2)	100 (10.8)
Just about the right weight	1052 (65.2)	599 (64.5)
A little overweight	328 (20.3)	195 (21.0)
Very overweight	52 (3.2)	35 (3.8)
Breastfeeding practices		
Breastfed only	384 (22.2)	161 (17.3)
Mostly breastfed	333 (19.3)	205 (22.1)
Half breast/half formula	298 (17.2)	171 (18.4)
Mostly formula	170 (9.8)	93 (10.0)
Formula only	543 (31.4)	229 (32.2)

Table 4: Comparing Maternal Characteristics between the Total Eligible Sample (N=228) and the Sample with Complete Data used for the m-Logit Smoking Model (N=125)

Maternal Characteristics	**Total Eligible N=228**	**Model N=125**
Clinic Time, days (mean ± sd)	241.2 ± 104.4	232.8 ± 100.0
Parity, n (%)		
Primiparous	104 (49.8)	67 (53.8)
Multiparous	105 (50.2)	58 (46.4)
Race, n (%)		
White	180 (79.0)	99 (79.2)
Black	11 (4.8)	6 (4.8)
Asian	16 (7.0)	9 (7.2)
Hispanic	18 (7.9)	11 (8.8)
Other	3 (1.3)	0 (0)
Education, n (%)		
Did not complete H.S.	31 (13.7)	11 (8.8)
Completed H.S./ GED	103 (45.4)	56 (44.8)
Vocational or trade school	15 (6.6)	7 (5.6)
College	76 (33.5)	49 (39.2)
Graduate School	2 (0.9)	2 (1.6)
Income, n (%)		
$0-500/mo.	2 (0.9)	0 (0)
$501-100/mo.	16 (7.2)	10 (8.0)
$1001-1500/mo.	39 (17.5)	18 (14.4)
$1501-2000/mo.	59 (26.5)	24 (19.2)
$2001-2500/mo.	46 (20.6)	29 (23.2)
$2501-3000/mo.	25 (11.2)	17 (13.6)
$3001-6250/mo.	35 (15.7)	26 (20.8)
>$6250/mo.	1 (0.5)	1 (0.8)
Married/living with partner, n (%)		
Yes	209 (91.7)	117 (93.6)
No	19 (8.3)	8 (6.4)
Active Duty		
Yes	42 (18.4)	31 (24.8)
No	186 (81.6)	94 (75.2)
Maternal Height, cm (mean ± sd)	164.1 ± 6.3	164.4 ± 6.5
Maternal Age, years (mean ± sd)	24.3 ± 5.5	25.2 ± 5.7
Baby's birth weight, g (mean ± sd)	3358.7 ± 534.4	3400.5 ± 571.5

Table 5: Comparing Outcome Variables between the Total Eligible Sample (N=228) and the Sample with Complete Data used for the m-Logit Smoking Model (N=125)

Outcome Variables	**Total Eligible N=228**	**Model N=125**
Maternal Weight Retention, kg (mean ± sd)	6.4 ± 7.5	6.8 ± 7.7
Weight Cycler, n (%)		
Yes	97 (42.5)	58 (46.4)
No	131 (57.5)	67 (53.6)
Prepregnancy weight perception, n (%)		
Underweight	19 (8.4)	9 (7.2)
About the right weight	102 (45.1)	53 (42.4)
A little overweight	77 (34.1)	48 (38.4)
Very overweight	28 (12.4)	15 (12.0)
Worried about shape during last week, n (%)		
None/rarely	46 (23.6)	27 (21.6)
Sometimes	70 (35.9)	44 (35.2)
More than half, but not most	46 (23.6)	29 (23.2)
Most or all of the time	33 (16.9)	25 (20.0)
Worried about food during last week, n (%)		
None/rarely	73 (37.4)	44 (35.2)
Sometimes	65 (33.3)	40 (32.0)
More than half, but not most	31 (15.9)	21 (16.8)
Most or all of the time	26 (13.3)	20 (16.0)
Worried about appearance during last week, n (%)		
None/rarely	42 (21.1)	23 (18.4)
Sometimes	83 (41.7)	50 (40.0)
More than half, but not most	48 (24.1)	35 (28.0)
Most or all of the time	26 (13.1)	17 (13.6)
Worried about weight during last week, n (%)		
None/rarely	58 (29.6)	34 (27.2)
Sometimes	64 (32.7)	38 (30.4)
More than half, but not most	40 (20.4)	27 (21.6)
Most or all of the time	34 (17.4)	26 (21.8)
Desire to gain/lose weight, n (%)		
Want to gain weight	8 (3.7)	4 (3.2)
Want to stay the same weight	25 (11.5)	11 (8.8)
Want to lose a little weight	151 (69.6)	90 (72.0)
Want to lose a lot of weight	33 (15.2)	20 (16.0)

Weight as a little girl, n (%)		
Underweight	34 (18.2)	24 (19.2)
Just about the right weight	120 (64.2)	77 (61.6)
A little overweight	29 (15.5)	22 (17.6)
Very overweight	4 (2.1)	2 (1.6)
Grandmother's usual figure		
Underweight	32 (15.0)	18 (14.4)
Just about the right weight	81 (38.0)	49 (39.2)
A little overweight	94 (44.1)	54 (43.2)
Very overweight	6 (2.8)	4 (3.2)
Breastfeeding practices		
Breastfed only	64 (28.1)	27 (21.6)
Mostly breastfed	43 (18.9)	28 (22.4)
Half breast/half formula	42 (18.4)	28 (22.2)
Mostly formula	26 (11.4)	11 (8.8)
Formula only	53 (23.2)	31 (24.8)

Table 6: Multiple logistic regression (n=934) with postpartum smoking as the outcome. Pseudo R squared 0.15

Category 0: Did not smoke postpartum (includes nonsmokers and quitters during pregnancy who did not relapse postpartum)
Category 1: Smoker postpartum (includes women who smoked during and after pregnancy, women who quit during pregnancy and relapsed postpartum, and women who did not smoke during pregnancy but reported smoking postpartum)

	OR	(95% CI)	
Postpartum weight retention	**0.97**	**0.94**	**1.00***
History of weight cycling	**1.74**	**1.18**	**2.56****
Prepregnancy weight perception	0.79	0.59	1.05
Body image	1.11	0.89	1.39
Height	**1.06**	**1.03**	**1.09*****
Black	**0.51**	**0.27**	**0.95***
Asian	**0.26**	**0.11**	**0.61****
Hispanic	0.62	0.37	1.04
Other race	0.97	0.29	3.18
Age	0.96	0.92	1.01
Active duty status	1.00	0.62	1.59
Married/living with partner	0.86	0.41	1.77
Parity	1.09	0.88	1.35
Income	0.90	0.79	1.03
Education	**0.68**	**0.57**	**0.81*****
Desire to gain/lose weight	1.22	0.95	1.56
Baby's birth weight	**.9995**	**.9992**	**.9999****
Weight as a young girl	**1.30**	**1.02**	**1.67***
Maternal grandmother's usual figure	1.08	0.97	1.21
Feed mostly breast milk	1.17	0.69	1.98
Feed half breast/half bottle	1.45	0.84	2.48
Feed mostly formula	0.87	0.44	1.73
Feed only formula	**0.51**	**0.29**	**0.88***
Time	1.00	1.00	1.00

(reference groups: race – white; income less that $500/month; baby's food – breastfeeding only)

* p<.05; ** p<.01; *** p<.001

Table 7: Significant associations using m-Logit model, with trichotomized smoking categories as the outcome (n=125). Pseudo R squared 0.26

Category 0: the woman smoked throughout pregnancy
Category 1: the woman quit smoking during pregnancy and relapsed postpartum
Category 2: the woman quit smoking during pregnancy and did not relapse postpartum

In comparison to women who smoked throughout their pregnancy:

Women who quit smoking during pregnancy and relapsed postpartum were more likely to be:

	OR	(95% CI)	
Mother's usual figure	1.46	1.06	2.02 *

Women who quit during pregnancy and did not relapse postpartum were more likely to be:

	OR	(95% CI)	
Postpartum Weight Retention	1.14	1.03	1.27 *
Asian	38.21	2.75	530.92 **
Baby's Birth weight	1.001	1.000	1.002 *
Education	2.43	1.32	4.46 **

In comparison to women who quit smoking during pregnancy but relapsed postpartum:

Women who quit during pregnancy and did not relapse postpartum were more likely to be:

	OR	(95% CI)	
Education	1.86	1.03	3.35 *

* p<.05; ** p<.01; *** p<.001