Does tobacco retailer availability influence

changes in smoking from pregnancy to postpartum?

By

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CERTIFICATE OF APPROVAL

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ABSTRACT

There is a growing literature reporting a pattern of associations between the built environment and the initiation or continuance of consumptive behaviors such as drinking and smoking. We investigated the role of the tobacco retail environment on smoking behaviors, particularly smoking cessation attempts of pregnant women. Home residences of participants in the Oregon Pregnancy Risk Assessment Monitoring System and tobacco retailers were geocoded and linked in a geographic information system. A multinomial logistic regression was utilized to model the relationship between smoking behaviors and tobacco retailers within participant-specific neighborhoods, comparing women that relapsed postpartum and women that smoked throughout pregnancy and postpartum with women that maintained successful cessation attempts 2 to 6 months postpartum.

When compared with women who successfully quit smoking during pregnancy, the density of tobacco retailers was not associated with women relapsing (Relative Risk Ratio, RRR, 1.02, 95% CI, 0.93, 1.14) or continuing to smoke throughout pregnancy and postpartum (RRR 1.04, 95% CI, 0.93, 1.15) in high population density areas of Clackamas, Multnomah, and Washington counties. In low population density areas of the Portland Tri-county region, the presence of tobacco retailers was inversely associated with relapsing (RRR 0.22, 95% CI, 0.05, 0.99) and trending in the same manner with sustained smoking (RRR 0.36, 95% CI, 0.09, 1.44). These results suggest that 1) the retail environment may be more important for the initiation of consumptive behaviors than their cessation in high population density areas, and 2) that the relationship between retailers and smoking behaviors may be complex in low population density areas.

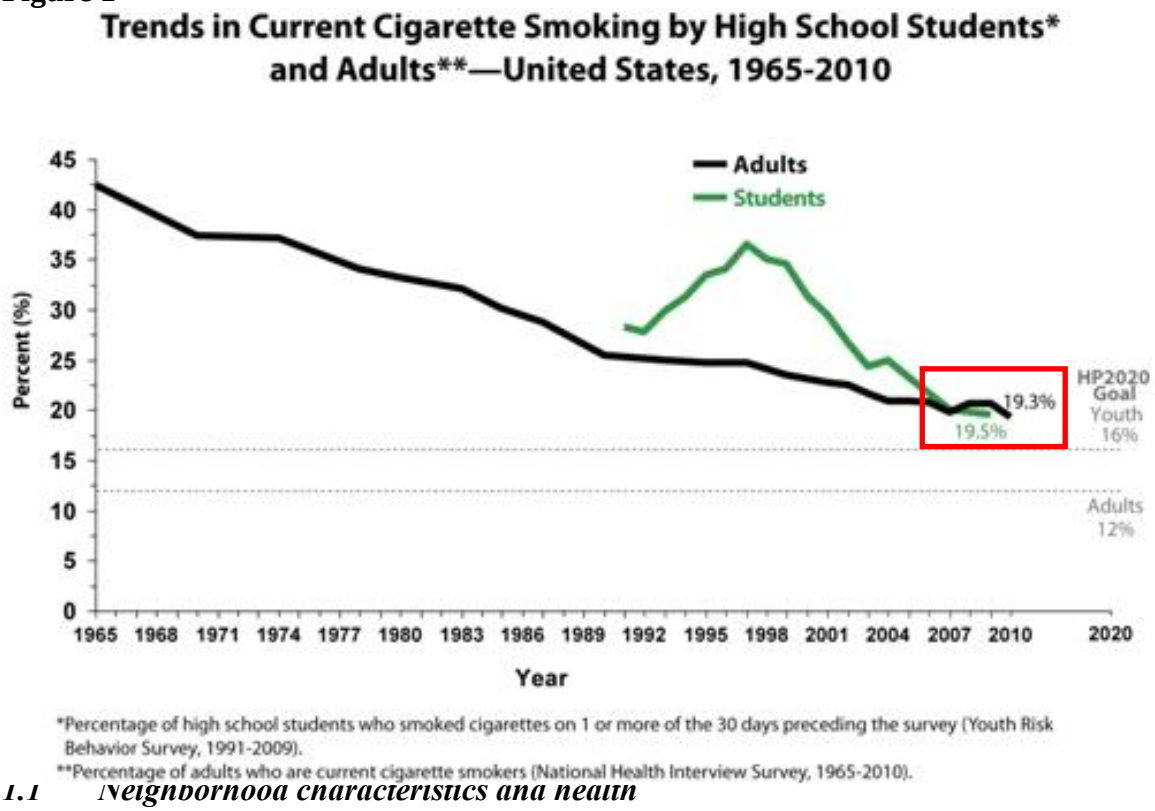
INTRODUCTION

In the 1930s, insurance companies realized the association between smoking and several types of oral cancers.[1] Concurrently, pathologists and physicians began to notice an increase in the previously uncommon occurrence of lung cancer.[2,3] Twenty years later, two groundbreaking case-control studies suggested an association between tobacco and lung cancer.[4,5] Associations between tobacco use and coronary artery disease,[6] chronic obstructive pulmonary disease,[7] and a variety of other cancers soon followed.[8,9] Today, it is recognized that tobacco has widespread detrimental effects on almost every major organ system, as well as potential lifecourse impacts, where exposure as early as in utero can have negative lifelong consequences.[10,11]

Not surprisingly, public health activities directed at reducing the initiation of smoking and promoting smoking cessation have a long history. In addition to the discovery and dissemination of the health outcomes associated with smoking and environmental tobacco smoke, public health-driven policies have played a role in creating smoke free workplaces,[12] requiring warning labels,[13] and increasing excise taxes on cigarettes.[14] The combined effect of these activities and many others, has been a steady decline in tobacco use by adults in the United States from 42% in 1965 to 19% in 2005.[15] Unfortunately, despite the reduction in the prevalence, smoking is still the number one cause of preventable disease and death in the United States.[16] Furthermore, the long steady decline has abated, and from 2005 to 2010 the prevalence of adult smoking in the United States has remained relatively steady at approximately 19% (Figure 1, red box).[15] New efforts to reengage smoking prevention and cessation are vital for continued reductions in smoking and achievement of the national goal of 12% smoking prevalence

in adults. Examining modifiable environmental influences during critical life transitions may be a promising strategy for long term change with population-wide health benefits.[17]

Figure 1



1.1 Neighborhood characteristics and health

Social ecological theory applied to the public health domain posits that influences at multiple levels, ranging from the individual- to community- and macro-level, influence health behavior and outcomes. That is, individual characteristics, social groups, communities, and environmental resources impact choices that have health related implications.[18] A growing literature reports associations between neighborhood factors such as retail stores and restaurants, and behaviors of consumption that affect health such as eating, drinking, and smoking,[19–23] supporting the importance of multi-level influences.

Retailers are not randomly dispersed throughout a geographic area, but located in response to economics, zoning regulations, history, and a variety of other factors.[24] The nonrandom retail environment can create inequities in exposure to different types of retailers and their associated storefront or in-store advertising.[25,26] By design, advertising is meant to prompt specific consumer behaviors and the extent of the annual investment made by the tobacco industry into advertising and promotion, $8.37 billion in 2011, with 90% of these funds directed towards the retail environment,[27] substantiates its effectiveness.

1.2 Alcohol retailers as an archetype for built environment research

Alcohol retailers are one example of a neighborhood variable that has received perhaps the most thorough examination to date. The international scope of the research, relative ease of identifying alcohol retailers due to licensing regulations, as well as the severity of the outcomes, such as drunk driving and domestic abuse, has led to cross-disciplinary interest from criminologists, economists, and public health researchers.[28] The first studies demonstrated that alcohol retailers in the United States were predominantly located within racial and ethnic minority communities.[29] Research then progressed to determine that increased alcohol retailer density was associated with the initiation of alcohol consumption,[30] the level of consumption in adults,[19,31] and alcohol related health problems such as motor vehicle crashes.[21]

The examination of the effects of alcohol retailers is significant beyond its contributions to that particular field of research because it has defined research trajectories for other less developed fields investigating impacts of neighborhood

features. In terms of methodology, alcohol retailer research has already broken trail on a variety of ways to investigate retailers as an exposure variable of interest and the use of appropriate analytical tools, including multilevel modeling and spatial analysis techniques.

Furthermore, the alcohol literature also serves as an important parallel illustrating the potential efficacy of regulatory initiatives such as limiting the number and location of retailers, as well as operating hours. The success of these types of policies in reducing alcohol consumption and related injuries, violence, and crime reinforces the notion that retailers are a important modifiable aspect of the built environment that can impact health related behaviors.[32,33]

1.3 Tobacco retailers are differentially located with respect to socioeconomic characteristics

Although still developing, research involving tobacco retailers and smoking behaviors is following the same trajectory as alcohol retailer research. Initial studies focused on the relationship between the socioeconomic characteristics of geographically defined areas and the number of tobacco retailers. Although results were mixed, these studies generally found a greater density of tobacco retailers in areas with lower median household income, lower average per capita income and higher percentages of Hispanic and African American residents.[34–41] The majority of this work has not only been cross sectional, but focused on census tract- or county-level units of analysis.

One study that has examined individually defined neighborhood exposures found largely similar results. In San Diego County the distance between home residence and

tobacco retailers was directly associated with the education levels and the percentage of owner occupied homes, and inversely associated with the percentage of families living below poverty, unemployment, population under 18, single mother household, and the percentage of Hispanics.[42]

1.4 Tobacco retailer impact on smoking initiation and volume: measurement and target populations

West et. al. determined that closer proximity of retailers to the homes of high school students was directly associated with greater alcohol and tobacco use.[42] The findings of this study are supported by two additional studies that examined individual smoking behaviors within census defined geographic units. In Chicago, tobacco retailer density was associated with greater risk of smoking in 11 to 23 year olds[41] and in California, density and distance to convenience stores, but not counts of convenience stores, were associated with a greater number of cigarettes smoked by adults in the prior month.[34]

The three studies described above are somewhat unique as the vast majority of the literature concerned with smoking behaviors and tobacco retailers has focused on retailers in relation to schools rather than homes, with the intention of identifying risk factors for initiation of smoking among adolescents. In research focusing on school locations, the density of retailers is positively associated with experimental smoking,[43] the likelihood of purchasing cigarettes rather than acquiring them from other sources,[44] smoking initiation in 6th through 8th grade students,[45] and prevalence of smoking in high schools.[46]

1.5 Are tobacco retailers associated with smoking cessation?

Although there is a relationship between tobacco retailers and smoking and between alcohol retailers and drinking, both fields are bereft of studies examining the role that retailers may play in the success or failure of cessation attempts. To my knowledge, only one study has been performed examining proximity of tobacco retailers and smoking cessation in adults. This study assessed 6 months of sustained abstinence from smoking in a diverse sample of adults attempting to quit in Houston, TX. The proximity of the closest tobacco retailer to one's residence was a significant predictor of continued smoking abstinence, but density of tobacco retailers was not.[47]

There may be a number of reasons why the relationship between tobacco retailer availability and smoking cessation has received very little attention. One reason may be that smoking cessation is a difficult behavior to accurately study as it is often a dynamic process composed of numerous quit attempts over extended periods of time.[48] The dynamic nature suggests that single point measures in time are unlikely to reflect the true smoking status of an individual and may lead to misclassification of outcome measures. Multiple samples over time or continuous monitoring are likely to give more reliable results, but at prohibitively high costs. Furthermore, extended follow up times need to address the dynamic nature of the built environment to account for retailers opening and closing as well as individuals changing residences (if examining the built environment around home residence).

1.6 Pregnant women are a unique population to study smoking cessation

Because maternal smoking is associated with poor birth and neonatal outcomes as well as adverse health events throughout the life course of the child, expecting mothers are exceptionally motivated to quit smoking. Evidence for this can be gleaned by comparing the smoking cessation rates of pregnant women, approximately 50% during pregnancy,[49–51] with a meta-analysis determined unaided 10 month quit rate among a heterogeneous population of approximately 7%.[52] Although women are motivated to quit during pregnancy, following delivery, new mothers are thrust into the stressful life transition of raising an infant. While life transitions present the opportunity for behavioral changes, those changes are not always positive and can often be the initiating event for substance abuse.[53] Therefore, not surprisingly, many women, up to 80% that quit during their pregnancy return to smoking by one year postpartum, thus only briefly attenuating the health risks to their children and themselves. [54,55]

This study attempted to advance the field by examining smoking behaviors, particularly in reference to cessation, of women across the critical life transition of pregnancy, in relation to tobacco retailer availability.

METHODS

2.1 Study population

Data were collected from birth certificates as well as the Oregon Pregnancy Risk Assessment Monitoring System (PRAMS), a cross-sectional survey concerned with the

behaviors and experiences of mothers before conception, during pregnancy, and postpartum for the years 2004 through 2007 inclusive. Data usage was approved by the Oregon Health Authority and the Oregon Health & Science University (OHSU) Institutional Review Board (IRB, #8890). The PRAMS survey is primarily administered through the mail, with a standardized telephone interview performed for mothers who don't respond to repeated mailings. A stratified systematic sample of Oregon residing mothers is selected from birth certificates up to 6 months after delivery of a live-born infant. Oversampling of four racial/ethnic groups (Hispanic, non-Hispanic African American, non-Hispanic American Indian/Alaska Native, non-Hispanic Asian) as well as white mothers of low birth weight infants is performed with the intention of capturing a larger portion of subpopulations than would occur with randomized sampling. [56] The intent of this process is to provide adequate statistical power to study subpopulation differences or target specific subpopulations. The sampling fraction for each subpopulation oversampled is adjusted yearly based upon state demographics for each subgroup in an effort to obtain a minimum of 300 respondents from each subgroup. Per Centers for Disease Control and Prevention recommendations,[57] datasets for the years 2004 through 2007 were joined to create a single analytic dataset by combining the Oregon specific stratification scheme and the sample year into a single variable.

Responses are weighted to correct for mechanisms that may introduce bias during the sampling process such as non-response, non-coverage, and oversampling. Non-response can introduce bias because characteristics related to individuals not responding may also be related to the exposure and outcome of interest. Weights to correct for non-response are generated post data collection by comparing the demographic characteristics

of non-respondents with respondents. Non-coverage can introduce bias because of clustering of non-responses that may occur due to the way that hospitals or counties release data. Weighting procedures associated with the PRAMS survey also correct for oversampling. The CDC is responsible for generating the weights with the intent of providing a representative sample of the entire population of women who deliver live-born infants in Oregon. The weighted response rates for the years 2004 through 2007 ranged from a low of 66.6% in 2007 to a high of 76% in 2005. Weights were utilized in this study, and a further discussion is given in the limitations section below.

2.2 Study variables

2.2a Smoking status

The smoking status of each PRAMS participant was determined at three different time points by their responses to a series of survey questions (Figure 2). The first question asked "Have you smoked at least 100 cigarettes in the past 2 years?" (Q29). An answer of 'No' directed respondents to the next survey section, while an answer of 'Yes' directed participants to the question "How many cigarettes did you smoke on an average day?" asked with respect to three different time points; 3 months before pregnancy (Q30), the last 3 months of pregnancy (Q31), and at the time of survey completion, 2-6 months postpartum (Q32). There were seven possible answers: 41 cigarettes or more, 21 to 40 cigarettes, 11 to 20 cigarettes, 6 to 10 cigarettes, 1 to 5 cigarettes, less than 1 cigarette, and none. Smoking at each time point was identified as 1 or more cigarettes prior to pregnancy (Q30), during the last 3 months of pregnancy (Q31), and 2 to 6 months

postpartum (Q32). All mothers who responded 'none' or 'less than 1 cigarette' to Q30, Q31, or Q32 were classified as nonsmokers for that time point.

We examined changes in smoking behaviors in women who smoked before pregnancy. This qualification limited the possible smoking behaviors across the three time points to four potential outcomes (Figure 2). Sustained Quitters stopped smoking during pregnancy and remained quit postpartum. Relapsers quit during pregnancy, but returned to smoking postpartum. Sustained Smokers reported smoking before and during pregnancy as well as postpartum, and the fourth outcome, Delayed Quitters, smoked before and during pregnancy, but not postpartum. Close to 20% of the 7728 PRAMS participants in Oregon from January 2004 through December 2007 were smoking before pregnancy. This unweighted prevalence was in accordance with the 2004 adult female smoking prevalence in Oregon (18.7%),[58] and nationally 2004 (18.5%).[59] Because of the small number of women who postponed quitting until postpartum, Delayed Quitters (n=47) were excluded from further analysis.

Figure 2. Outcome categories determined from smoking status at each time point, as determined by the PRAMS questionnaire

3 months before pregnancy	Last 3 months of pregnancy	2 to 6 months postpartum	Outcome Category	n
Smoker Q29. Yes AND Q30. Any response greater than < 1 cigarette	**Nonsmoker** Q31. None' OR < 1 Cigarette'	**Nonsmoker** Q32. 'None' OR '< 1 Cigarette'	Sustained Quitter	433
		Smoker Q32. Any response greater than< 1 cigarette	Relapser	316

	Smoker Q31. Any response greater than < 1 cigarette	**Smoker** Q32. Any response greater than < 1 cigarette	Sustained Smoker	735
		Nonsmoker Q32. 'None' OR '< 1 Cigarette'	*Delayed Quitter	47

*Delayed Quitters were excluded from further analysis.

2.2b Neighborhood environment

Neighborhood environment data of Portland Tri-county area (Multnomah, Clackamas, and Washington) residing PRAMS participants were created and linked as part of a related study approved by the OHSU IRB (#7976). The approved security protocol for linking PRAMS respondent locations with neighborhood environment data was established through a coordinated effort between OHSU and the Oregon Health Authority (Appendix A) and performed by Alfredo Sandoval at the Oregon Center for Health Statistics and Ashley Howell at OHSU.

2.2b.1 Tobacco retailers (primary exposure variable)

Tobacco retailers were identified from multiple sources because the state of Oregon licenses tobacco distributors and not retailers, precluding the existence of a single comprehensive listing. Non-age restricted tobacco retailers were obtained from the Addiction and Mental Health Division (AMH) of the Oregon Health Authority. The AMH implements the Synar program, federal legislation purposed with preventing the sale of tobacco to minors. Age-restricted retailers were collected from the annual quarterly census employment and wages file (Oregon employment records) provided by the Oregon Employment Department. Utilizing the North American Industry Classification System (NAICS), "tobacco stores", coded as NAICS 453991, were

extracted from Oregon employment records for each year 2004 through 2007 inclusive. These records were merged with Synar records and duplicates according to name and address were removed. The compilation of year-specific tobacco retailers was overlaid with participant-specific neighborhood boundaries (described below) to yield the number of tobacco retailers in each woman's neighborhood in the year of PRAMS survey participation.

2.2b.2 Respondent-specific neighborhood boundaries and variables (completed by Ashley Howell)

The latitude and longitude coordinates of PRAMS respondents were projected into a geographic information system. Euclidean buffers with a 1 km radius around each respondent's home were created to delineate respondent-specific neighborhoods. A 1 km distance represents a 10 to 20 minute walk in any direction from the respondent's home address, and approximates distances often chosen for neighborhood availability studies. Neighborhood measures were also created for 3 km, 5 km, and 8 km buffers that may warrant further investigation.

Population counts and neighborhood sociodemographic information were obtained from United States Census 2000 block group-level data. To create buffer-based measures of population and neighborhood sociodemographic characteristics, block group data were apportioned into 1 km neighborhood buffer areas. Apportioning is a means of attributing the values for a geographic unit to regions of interest that are a fraction of the entire unit area. In this instance, the underlying assumption is that the values are distributed homogeneously throughout the census block group. For respondent-specific

buffers that were contained within a single census block group, the attributes of that census block group were apportioned according to the size of the buffer relative to the size of the census block group. For example, the area of a 1 km radius Euclidean buffer is 3.14 km^2 (assuming no disruptions such as waterways). If the area of the census block group was 6.28 km^2, half of the population in that block group would be attributed to be within the buffer. In cases where neighborhood buffers extended over several census block groups, values for neighborhood measures were apportioned based on the percentage of the area of the buffer within each census block group. This approach allowed for the generation of relatively small, respondent-specific neighborhoods, that were not limited to nonoverlapping census defined geographical units. The average population within the buffer and a neighborhood socioeconomic deprivation index were calculated in this manner for all geocoded PRAMS participants.

Census block groups range in size from 600 to 3000 persons which approximates the population within 1 km radius Euclidean buffers within the sample. Therefore, the resolution of the data obtained from the census block groups approximates the finest constructed measure, suggesting that more nuanced apportioning approaches may not be necessary and a homogeneous distribution is a reasonable approximation for the purposes of this study. However, it should be noted that error would be expected to increase as buffer sizes increase and more census block groups need to be apportioned.

2.2c Potential Confounders

2.2c.1 Individual Level

Additional characteristics known or presumed to be associated with smoking were collected from birth certificates and the PRAMS survey. Birth certificate-derived

covariates included maternal age, maternal education, marital status, and birth order. Maternal age was the number of years alive, in whole numbers, at the time of delivery of the infant and for the purpose of this study was considered as a continuous variable. Maternal education, an ordinal variable, was collected as the number of grades completed, but was collapsed into three categories; less than high school degree, high school degree, and some college or college degree. Marital status, collected from birth certificates was reported in two categories, either married/separated (married) or unmarried/divorced/annulled/not reported (unmarried/divorced). Previous live births, collected as a continuous variable, were also collapsed into categories (0, 1, 2 or more). All of the potential confounders identified from the birth certificate data have been previously associated with smoking behaviors, or with lifestyle activities that may be associated with smoking behaviors. [60,61]

PRAMS-derived characteristics included income, maternal race/ethnicity, the month of first prenatal care, depressive occurrences during pregnancy, the average number of cigarettes smoked before pregnancy, and residence with a smoker. Total household income was determined from question 64 of the PRAMS survey and converted into a percentage of the federal poverty line (income) with respect to the year of the survey. The race/ethnicity of mothers was dichotomized into two categories based upon the need to have an adequate number of women in each group. The first and largest category was White non-Hispanics. The second category, non-white/Hispanic, was constructed from the combination of four designations from the PRAMS survey; Hispanic, non-Hispanic African American, non-Hispanic American Indian/Alaska Native, non-Hispanic Asian. Dichotomizing race and ethnicity is unfortunate as prior

research suggests that smoking prevalence differs across race/ethnicity, but was necessary to ensure adequate cell counts.[60] Prenatal visits often include information about the risks smoking presents to the fetus as well as advice to quit smoking and therefore may be associated with which women quit.[62] The month of first prenatal care visit was derived from the question 16 of the PRAMS survey, "How many weeks or months pregnant were you when you had your first visit for prenatal care? Do not count a visit that was only for a pregnancy test or only for WIC". All mothers who completed the question were considered to have received prenatal care and were categorized as either receiving prenatal care in the first trimester, or in the combined second/third trimesters. Depression during pregnancy was assessed with PRAMS question 68a "While you were pregnant, how often did you feel down, depressed, or hopeless?" with possible answers being "always, often, sometimes, rarely, never." These responses were collapsed into categories for always/often or sometime/rarely/never. Information was also collected concerning the average number of cigarettes smoked per day before pregnancy from PRAMS question 31. As described previously, there were seven possible answers, five of which were considered as smoking in this study: 41 cigarettes or more, 21 to 40 cigarettes, 11 to 20 cigarettes, 6 to 10 cigarettes, and 1 to 5 cigarettes. Groups were collapsed into three categories to allow for adequate counts; 1 to 5, 6 to 10, and 11 or more cigarettes. Smoking volume can be considered as a measure of dependency and has been associated with the success of quit attempts.[63] Whether or not PRAMS respondents lived with other smokers in the household was ascertained from question 78 of the PRAMS survey; "Not including yourself, is there anyone in your household who smokes cigarettes, cigars, or pipes?" with possible answers of 'Yes' or 'No'. In addition to

environmental characteristics, household influences, particularly living with a smoker, have been demonstrated to be strongly associated with smoking behaviors. [64–66]

2.2c.2 Neighborhood Level

A neighborhood deprivation index was created (by Ashley Howell) based on prior work by Messer et al (2006) using 2000 census block group level data. The literature has demonstrated that tobacco retailers are more likely to be located in minority and economically disadvantaged neighborhoods. [34–41]

2.3 Analytic sample

There were 7728 PRAMS participants in Oregon between January 2004 and December 2007 and 1484 of the 1531 women who smoked before pregnancy exhibited smoking behaviors with adequate frequency for further analysis; Sustained Quitters, Relapsers, and Sustained Smokers. Of the 1484 women, 586 reported a home address within the Portland Tri-county area. Information concerning maternal behaviors and characteristics was missing from 48 additional women. The majority of missing information concerned income (n=37) with additional missing information involving depressive status during pregnancy (n=5), education (n=3), residence with a smoker (n=2) and race/ethnicity (n=1). The final analytical sample was comprised of 538 women residing in the Portland Tri-county Area (Figure 3). For all analyses, the Stata survey (svy) function was used to apply weights to correct for oversampling and stratified sampling design, and the STATA subpopulation (subpop) function was used to include all 7728 participants in the calculation of the standard errors.

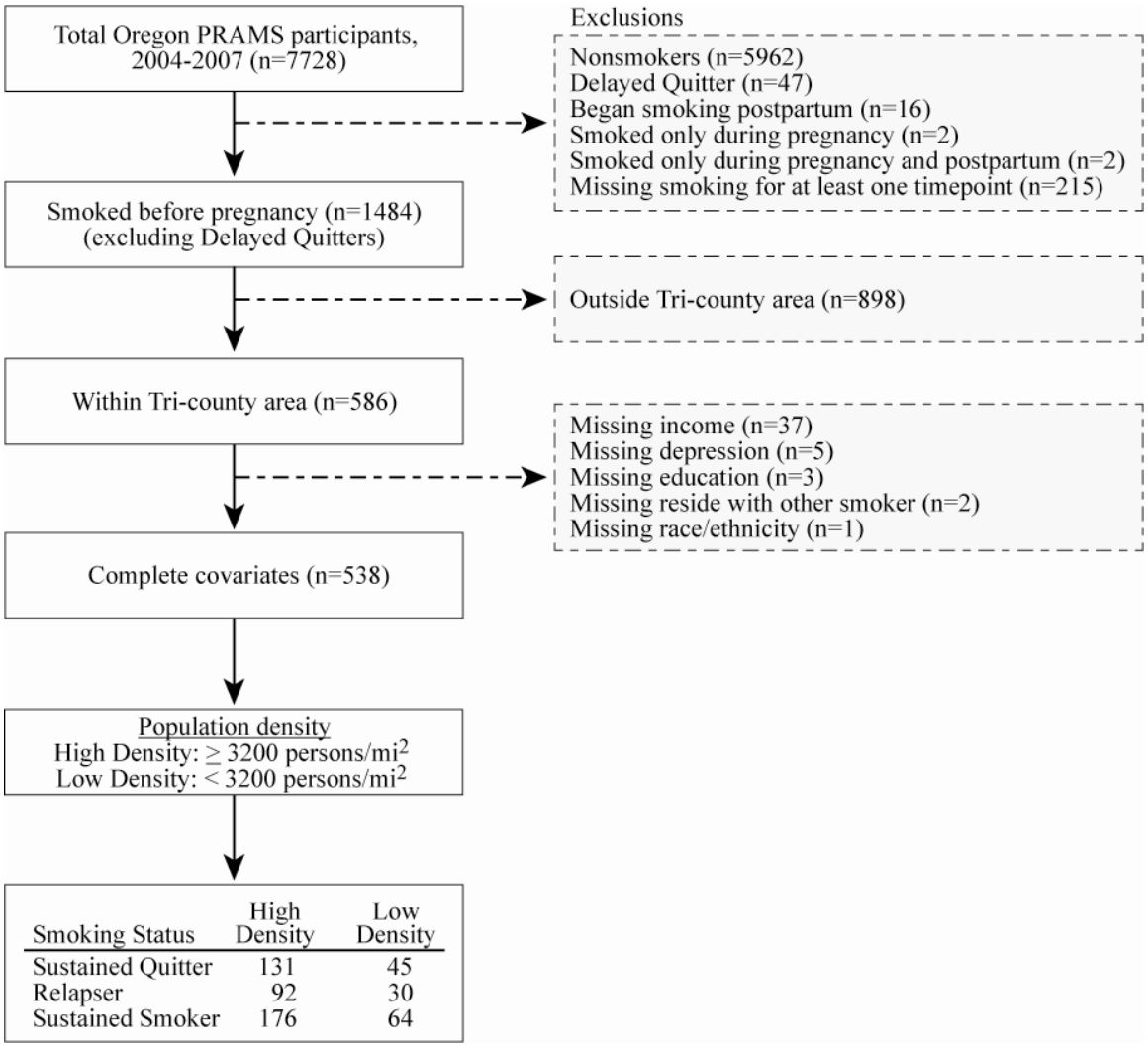
2.3a Respondent-specific neighborhood density

Although all study participants in the final analytic sample resided in the Portland Tri-county area, participant's neighborhoods were widely variable with respect to population density, ranging from 9 persons per mi^2 to 11155 persons per mi^2. The wide range in population density is likely to obfuscate the relationship between tobacco retailers and smoking behaviors as retailer/consumer interactions are likely to vary across the range of population density. Therefore, the analytic sample was separated at a threshold density of 3200 persons/mi^2, approximately equivalent to houses on lots of 0.5 to 5 acres, or low-density suburbs (Figure 3).[67] Mid-density suburbs, houses on lots of 0.2 to 0.5 acres, and dense urban neighborhoods are generally characterized by population densities above 3200 persons/mi^2. This separation also facilitated statistical modeling as the relationships between the log odds of the smoking behaviors, (either Relapsers or Sustained Smokers with Sustained Quitters as the referent) departed from linearity with respect to continuous measures of tobacco retailers when the entire analytic sample was evaluated, but were linear when the subpopulation of women residing in higher population density areas of the Tri-counties were examined.

Of the 538 women, 399 of the participants resided in mid-density or denser locations (high density; average density: 5688 $\pm$ 1578 persons/mi^2) and 139 women resided in low density or rural settings (low density; average density; 1573 $\pm$ 1029 persons/mi^2). The proportions of women in each outcome category; Sustained Quitter, Relapser, or Sustained Smoker was not different between high and low population density designations. The total number of women in each stratum, as described in

Hosmer and Lemeshow, should be at least minimally sufficient for multinomial logistic regression modeling.[68]

Figure 3. Formation of the analytic sample



2.3b Population density based tobacco retailer measures

For PRAMS participants residing in locations likely to have more than one tobacco retailer within a 1 km buffer, such as mid-density suburbs and urban locations, a density of tobacco retailers within each respondent-specific buffer was calculated. The

total number of retailers within each respondent specific buffer was divided by the population within each buffer (described above) and multiplied by 10,000. This type of measure is preferable to simple counts as it takes into account some of the variability in population density between neighborhoods. Tobacco retailer density will be examined among women residing in the high population density areas of the Tri-county region, and the presence or absence of a retailer will be examined among women residing in the low population density areas of the Tri-county region, where participants may be unlikely to have more than one tobacco retailer within a 1 km of their residence.

2.4 Analyses

2.4a Descriptive analyses

Initial descriptive analyses consisted of cross tabulations of outcomes with exposure variables and potential confounders (Table 1). Categorical variables with small numbers were collapsed to ensure adequate cell counts.

2.4b Multivariable analyses

A multinomial logistic regression was utilized to model the association between tobacco retailers and smoking outcomes across three time points related to pregnancy; Sustained Quitter (referent outcome), Relapser, and Sustained Smoker, stratified by population density of residence. Stata 9.0 (StataCorp LP, College Station, TX) was utilized to perform the multinomial logistic regression as it allows for designation of a referent category group using the syntax "base," with comparisons being made between all categories and the designated referent category. All neighborhood measures were

individual-level based, and because women were not sampled according to geography, area-level clustering was expected to be negligible.

A manual, forward, stepwise approach employing change-in estimate methodology as described by Greenland was followed to build the models.[69] In the first step, for high density residing women, bivariate multinomial logistic regressions were performed with the primary exposure variable, tobacco retailer density, and each covariate. All covariates that resulted in a 10% or greater change in the coefficient of the primary exposure variable with respect to either of the two multinomial regression outcomes (Relapsers and Sustained Smokers, compared to Sustained Quitters, the referent outcome) were considered to be potential confounders (Appendix B1). Step 2 involved adding the potential confounders identified in step 1 in decreasing order of the percent change produced in the coefficient of the primary predictor. After the addition of each potential confounder to the model, the new coefficient of the primary predictor was compared to the coefficient of the primary predictor in the prior iteration of the model, and if the change was greater than 10%, the variable was kept in the model. This process was repeated for each potential confounder identified in Step 1 (Appendix B1). The entire process was then repeated for low population density residing participants using the alternative tobacco retail measure (present/absent; Appendix B2). However, in an effort to prevent overfitting the model to the relatively small sample size of the low population density residing participants, a more conservative change in estimate criterion of 20% (instead of 10%) was utilized.

For each model, collinearity among independent variables was assessed by examining standard errors following the addition of each variable to the models.

Substantially inflated standard errors could be indicative of collinearity, but were not apparent with any of the variables in this study. After the preliminary models were created for participants residing in either high or low population density areas, interactions between income and tobacco retailers were tested by adding interaction terms to the model and testing for significance with the testparm function. Interactions were not significant for either high population density ($p = 0.27$) or low population density ($p = 0.76$) residing women. Linear relationships between the log odds of smoking behaviors, (either Relapsers or Sustained Smokers with Sustained Quitters as the referent), were observed for each of the continuous variables (maternal age, average neighborhood deprivation index, income, and tobacco retailer density) without scaling (quadratic, cubic, etc…), for participants residing in either high or low population density areas as determined with the nlcheck function of STATA. (Appendix C). Use of the survey command in STATA precluded residual analyses and diagnostics.

RESULTS

Slightly more than half of the women who smoked before pregnancy did not smoke during the last 3 months of pregnancy (55%). Of the women who quit smoking during pregnancy, 41% were smoking again 2 to 6 months postpartum, and approximately 45% of women who smoked before pregnancy continued to do so during and after pregnancy (Table 1). There were no differences in smoking behaviors based on the location (high vs low population density) of the respondents.

3.1 Descriptive characteristics

Among high density residing PRAMS participants, the average number of tobacco retailers per 10,000 persons within respondent specific buffers was similar for all three smoking outcomes (Table 1). Sustained Smokers were younger, poorer, and lived in more deprived areas than Sustained Quitters. Relapsers were also younger than Sustained Quitters. Additionally, the frequency of characteristics of high density residing Relapsers were often intermediate to the frequency of characteristics of Sustained Quitters and Sustained Smokers. For example, 54% of Relapsers resided with another smoker, compared with 34% of Sustained Quitters and 66% Sustained Smokers. A similar pattern was observed for most of the other categories examined; race/ethnicity, income, deprivation index, educational attainment, depression, trimester of first prenatal care, and average number of cigarettes smoked per day before pregnancy (Table 1).

Over half of low density residing Relapsers and Sustained Smokers had tobacco retailers within 1 km of their homes, as well as over 70% of Sustained Quitters. As observed in high density locations, low density residing Sustained Smokers had less income than low density residing Sustained Quitters. Differences were also noted among outcomes with respect to education and marital status, but overall there were fewer differences noted among the outcome groups of low population density residing PRAMS participants than high population density residing PRAMS participants (Table 1).

3.2 Bivariate models

Among high density residing PRAMS participants, tobacco retailer density was not associated with women being Relapsers or Sustained Smokers. Having a high school diploma or at least some college as well as increasing age were associated with a lower

risk of relapsing (RRR 0.13, 95% CI 0.04, 0.52; RRR 0.13, 95% CI 0.13, 0.48, respectively) or smoking through pregnancy (RRR 0.29, 95% CI 0.10, 0.91; RRR 0.10, 95% CI 0.03, 0.29, respectively). In contrast, being unmarried/divorced was associated with a higher risk of relapsing (RRR 5.2, 95% CI 1.73, 15.65) or smoking through pregnancy (RRR 4.43, 95% CI 1.82, 10.77; Table 2).

In low density population locations, the presence or absence of tobacco retailers was not associated with women relapsing postpartum or continuing to smoke through and beyond pregnancy. As observed with women residing in high population density areas, smoking at least six cigarettes per day before pregnancy were associated with a higher risk of being a Sustained Smoker (RRR 7.63, 95% CI 1.74, 33.48) and having at least a high school diploma was associated with a lower risk of being a Sustained Smoker (RRR 0.07, 95% CI 0.01, 0.40; Table 2).

3.3 Multivariate models

In women residing in high population density areas there was no association between tobacco retailers and being a Relapser or a Sustained Smoker after controlling for confounding (Table 3). Being unmarried/divorced resulted in higher risk of being a Relapser (RRR 4.87, 95% CI 1.28, 18.57) and having attended at least some college trended towards lower risk of being a Relapser (RRR 0.20, 95% CI 0.04, 1.08) or Sustained Smoker (RRR 0.31, 95% CI 0.08, 1.13). Income was associated with a lower risk of being a Sustained Smoker (RRR 0.992, 95% CI 0.988, 0.996).

In women residing in low population density areas, the presence of tobacco retailers was associated with a lower risk of being a Relapser (RRR 0.22, 95% CI 0.05,

0.99) and also trended towards a lower risk of being a Sustained Smoker (RRR 0.36, 95% CI 0.09, 1.43). Magnification of these associations after controlling for covariates suggests the important role of confounding in the relationship between tobacco retail availability and smoking cession and relapse. However, due to small sample size, estimates for all variables were exceptionally imprecise and the observed associations are unstable and may be spurious. For this reason, we do not discuss the estimated effects of confounders, and estimated effects of tobacco retailers should be interpreted with caution.

DISCUSSION

4.1 Tobacco retailers and smoking behaviors among women residing in high population density areas

The respondent-specific tobacco retail environment was not associated with smoking relapse postpartum or continued smoking through and after pregnancy in women residing in high population density areas of the Portland Tri-counties. The lack of an association in high population density areas was surprising given the observed impact the retail environment has on behaviors of consumption,[20–23] as well as the consistent findings of associations with retailers and the initiation of smoking.[45,46] It is possible that the retail environment is more influential in the initiation and maintenance of behaviors than in their cessation.

4.1a High levels of tobacco retailer availability

It is also possible that proximity of retailers may be more influential than retailer density. In the higher population density areas of Portland there was an average of nine tobacco retailers per 10,000 persons within 1 km of participants' homes without

accounting for additional retailers such as liquor stores and bars that are unlikely purchase points for pregnant women. This high average level of availability, at such a small scale, for a specific product may explain why no association was observed. If proximity is the important measure of exposure regarding retailers, as it was determined to be in Houston, TX,[47] and a single retailer within a certain minimum distance can affect one's behavior, it is possible that the Portland Tri-county area is saturated to the point where all individuals may reside within whatever that minimum distance may be.

4.1b Differences among consumptive behaviors

Alternatively, the behaviors of smokers in high population density areas may be predicated more upon price than retailer location. A strong association exists between price and cigarette use,[70] and individuals may purchase cigarettes online, make monthly trips to a warehouse club to purchase them in bulk, or roll their own in order to get the best price. Additionally, the mechanics of smoking are somewhat different than for other behaviors of consumption. Cigarettes are small, easily transported, have a long shelf life and can therefore be utilized at almost any time without the necessity of having a retailer nearby. This is not necessarily true for food which can spoil, takes time to prepare, and can be difficult to transport, or alcohol, which is often not accessible at almost any time.

4.2 Tobacco retailers and smoking behaviors among women residing in low population density areas

In low population density areas of the Portland Tri-county area a negative association was observed between the presence of tobacco retailers and smoking

behaviors. In opposition to the expected results, women had a lower risk of being Relapsers and were trending toward a lower risk of being Sustained Smokers if they resided near tobacco retailers. This was an intriguing finding but should be interpreted with caution as the instability of the relative risk ratios, evidenced by the small sample size and relatively wide confidence intervals within the model suggests that this may be a spurious finding.

Convincing underlying causes for this result are difficult to imagine, but one possible explanation involves the interplay between the retail and social environments in low population density settings. Retailers in less densely populated areas often carry a wide range of goods to meet the needs of people over a wider geographic area. Stores like Walmart, often situated at metropolitan fringes, epitomize this retail approach. In contrast, locations in city centers are often served by higher frequencies of smaller stories with limited inventories. It is possible that women residing in low population density areas who live near a tobacco retailer also live near a large store where they can purchase cigarettes as well as baby supplies. However, purchasing both types of items at the same time in their local neighborhood would likely be met with social ostracization. Social influences are known to be powerful drivers of smoking behaviors, and the resulting social pressure may make the simultaneous purchase of tobacco and baby products unlikely. In contrast, women who don't have a retailer in their neighborhood have to drive to a different neighborhood to purchase cigarettes (and baby supplies) where they may not be familiar with the social network and the social pressure may not weigh as heavily upon them. Thus, women who don't live near tobacco retailers may be more likely to be Relapsers or Sustained Smokers.

LIMITATIONS

Comparing smoking behaviors over three consecutive time points in a time naïve model created the possibility for selection bias because the selection criteria, smoking status, were related to the outcome of interest. With this in mind, nonsmokers were excluded in attempt to examine sustained smoking cessation, smoking relapse following cessation, and sustained smoking before, during and after pregnancy; all outcomes predicated upon smoking before pregnancy. While including nonsmokers would help ensure that all PRAMS subjects had similar likelihoods of being selected, it seemed unnecessary for a study focusing on smoking cessation. Furthermore, exclusion of nonsmokers allowed for the inclusion of an important potential confounder for any study examining smoking cessation, a proxy for nicotine dependence, the number of cigarettes smoked before pregnancy.

Only women residing in Clackamas, Multnomah and Washington Counties were included in the subpopulation for determining relative risk ratio estimates. However, PRAMS sampling was not stratified by county, suggesting that the weights used that were generated to correct for sampling bias for the entire state of Oregon may be biased. Further bias may have been introduced by splitting the analytic sample according to population density, thereby creating subpopulations that were likely to be even less similar to the demographics of the state of Oregon. Despite these concerns we chose to implement the weights to correct for oversampling by race/ethnicity and low birth weight, rather than relying on estimates derived from unweighted measures that we knew a priori to be biased. The extent of the bias in either scenario is difficult to determine.

Self-selection bias may exist with respect to residential as well as retailer locations.[71] People don't choose where they live randomly, but most likely do so with intention, and this may make the interpretation of any observed association unclear. For example, women who enjoy smoking and want to continue smoking may choose to live in a location that is replete with tobacco retailers. Since no measure of living intention was measured, an observed association could be attributed to the impact of the proximate retailers, when in fact, the women may live near tobacco retailers because they smoke. The same concept holds for tobacco retailers. Good business practice would suggest that retailers will locate in areas with high demand. Both situations make interpretations of any observed associations difficult.

Exposure misclassification is also a concern as the address reported for each woman was collected 2 to 6 months postpartum and may not be the address where the woman resided before and/or during pregnancy. Because it is survey data, outcome misclassification, particularly true smokers not reporting smoking behaviors is a possibility that would bias the association towards the null. Furthermore, a measure of intention to continue smoking cessation postpartum was not captured. Therefore, it is unknown how many of the women relapsed because of external factors, and how many of the Relapsers had no intention of maintaining cessation.

There are numerous aspects of the built environment such as point of sale and storefront advertising that are believed to be influential on smoking habits that were not included in this dataset. Likewise, numerous aspects of the social environment were not captured and are well known to influence smoking behaviors. Furthermore, this dataset

only considers the residential neighborhood, and not the workplace neighborhood which may be just as influential.

In regards to the spatial data, it was unfortunate that information about the proximity of retailers to PRAMS participant's homes was not available, as prior research suggests it may have been more informative than the density measures employed. Further limitations were imposed in order to maintain the privacy of the PRAMS participants. Utilizing neighborhood specific buffers removed many restrictions that can occur with nonoverlapping census borders. However, PRAMS participants located at the outer boundary of Clackamas, Multnomah and Washington counties would not have fully realized neighborhood buffers as they would extend into areas where data was not collected. Due to privacy concerns, it is difficult to estimate the scope of this problem, but it is likely to be small. Furthermore, respondent specific buffers could be represented in a more true-to-life fashion if they were constructed along network buffers, rather than Euclidean ones. Again, it is difficult to estimate the effect this may have. Another spatial limitation concerning effects that are difficult to quantify is the assumption of homogeneous distribution of attributes throughout census block groups. Finally, the GIS data has not been validated, and there may be unrecognized errors.

CONCLUSION

Retailers are associated with the initiation of a variety of behaviors of consumption involving food, alcohol, and tobacco. However, it remains unclear if there is a relationship between retailers and cessation of alcohol -and tobacco-related

behaviors. Recent policy initiatives to transform the built environment have been driven by hopes of altering behaviors. In the case of addictive behaviors such as tobacco, a more powerful argument may be to modify the built environment to reduce the likelihood of these behaviors from ever developing.

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Appendix A
Geographic linkage protocol for "Connecting Neighborhoods, Nutrition, and Developmental Origins of Disparities in Obesity-Related Health"

GIS linkage Protocol revised 11/28/2011 based on meeting with Jennifer Woodward, Joyce Grant-Worley, Ken Rosenberg, and Alfredo Sandoval

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PRAMS project proposal approved June 2011

To protect the confidentiality of PRAMS respondents, we will employ a strict security protocol for linking neighborhood data with individual-level PRAMS data. The analytical data file will contain PRAMS 2004-2007 survey responses, birth certificate data, and respondent-specific environment measures. For example, we will calculate percent of persons living below poverty in the census tract and block group in which the respondent resides. **The analytic data file will not contain any geographic identifiers more specific than the county**. With this overall strategy in mind, we propose the following procedure.

To be conducted by PRAMS personnel (Al Sandoval)

1. For 2004-2007 PRAMS respondents, create File A containing PRAMSID and two pseudo IDs (PID1 and PID2). PID1 and PID2 will uniquely identify each PRAMS respondent, but cannot be traced back to PRAMSID without access to Table A

   Table A example

PRAMSID	PID1	PID2
0021	063	098
0022	091	049
0023	025	056

2. Create Table B containing PID1 and geocoded latitudes (lat) and longitudes (long). Thus, this table provides information on exact residential locations of women who had a baby in Oregon and participated in the PRAMS survey. It DOES NOT contain <u>any</u> information about the women or children.

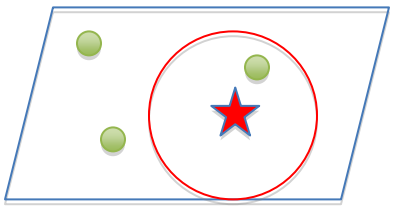
Table B example

PID1	Lat	Long
063		
091		
025		

3. Send Table B to OHSU GIS programmer in a password protected file via secure FTP site, CD-ROM, or other secure method.

To be conducted by OHSU GIS programmer at OHSU, all conducted on a secure workstation. Because unique combinations of environment variables could be linked back to these files, these files will only be accessible to the GIS programmer. They will <u>NOT</u> be accessible to researchers that have access to PRAMS health data.

4. Save Table B in secure location
5. Map respondent locations based on lat/longs provided in Table B. Integrate environment data for areas in which each PRAMS respondent lives in ArcGIS
6. In ArcGIS, create respondent-specific environment measures. In Figure below, the red star indicates a PRAMS respondent (PID1=063) home location, the blue parallelogram indicates the census tract, and red circle indicates the area within X miles from the respondent location, and green circles indicate the locations of supermarkets.



7. From ArcGIS, create a flat file (Table C) containing PID1 (pseudo ID #1) and a series of environment variables. For example, the number of supermarkets within the red buffer area (Super1), the number of supermarkets within the census tract (Super2), the census tract FIPS code (this will later be converted into a pseudo code), and percent of population below poverty. To further reduce possibility of deductive disclosure, we will round census proportions to 2 decimals (or whole percentage points).

Table C example

PID1	Super1	Super2	Census Tract	Block Group	Poverty (CT)	Poverty (BG)
063	1	3	4106703130	41067031301	0.70	0.67
091						
025						

8. Deliver Table C to PRAMS personnel (Al Sandoval) in a password protected file

via secure FTP site, CD-ROM, or other secure method.

9. Store the files in a third party location at OHSU for up to six months; after this time period, the files will be delivered to PRAMS personnel and destroyed at OHSU.

To be conducted by PRAMS personnel (Al Sandoval)

10. Link Tables C and A on PID1, then link to PRAMS survey and birth certificate data
11. Create Table D containing Census Block Group and Census Tract FIPS codes and pseudo FIPS codes. Access to pseudo FIPS will allow researchers to identify respondents living in the same census tract so that we can test and correct for clustering within census block groups in our statistical analysis.

Table D example

FIPS (CT)	FIPS (BG)	FIPS2 (CT)	FIPS2 (BG)
4106703130	41067031302	063	0631
4106703151	41067031513	091	0912
4106703161	41067031611	025	0253

12. Create Table E containing PID2, respondent-specific environment variables from Table C, pseudo FIPS codes (FIPS2), and PRAMS data. No geographic identifiers more specific than the county will be included in this file. PID2 will allow researchers to request additional data, but cannot be linked to Table E without Table A (housed by Al Sandoval).

Table E example

PID2	Super1	Super2	FIPS2 (CT)	FIPS2 (BG)	poverty	Race	Age	Birthweight*
063	1	3	063	0631	0.67	White	32	8
091								
025								

*or categorical if necessary

13. Obtain approval of Table D file by Oregon Center for Health Statistics.
14. Send Table E to OHSU researchers (Janne Boone-Heinonen) in a password protected file via secure FTP site, CD-ROM, or other secure method.

Appendix B1: Model Building. Potential confounders for women residing in areas of high population density. Primary exposure variable, tobacco retailer density. Change in the coefficient of the primary predictor following the addition of each covariate. Sustained Quitters were the referent group

	Relapser		Sustained Smoker			
	Coefficient (Tobacco Retailer Density)	Percent Change in Coefficient	Coefficient (Tobacco Retailer Density)	Percent Change in Coefficient	Greatest Absolute % Change in Coefficient	Order to Enter Into Model
Tobacco Retailer Density	0.0451	n/a	0.0377	n/a	n/a	n/a
+ Deprivation index	0.0129	-71.29	-0.0078	-120.64	120.64	1
+ Marital Status	0.0216	-51.96	0.0158	-58.01	58.01	2
+ Income	0.0394	-12.58	0.0247	-34.40	34.40	3
+ Maternal Education	0.0358	-20.44	0.0362	-3.90	20.44	4
+ Trimester of Prenatal Care	0.0479	6.34	0.0450	19.43	19.43	5
+ Maternal Age	0.0397	-11.95	0.0307	-18.61	18.61	6
+ Depression	0.0433	-3.99	0.0319	-15.29	15.29	7
+ Cigarettes smoked before	0.0416	-7.69	0.0357	-5.24	7.69	n/a
+ Birth Order	0.0480	6.46	0.0372	-1.32	6.46	n/a
+ Residence w/ Smoker	0.0465	3.25	0.0385	2.18	3.25	n/a
+ Race/ethnicity	0.0456	1.17	0.0383	1.65	1.65	n/a

Determination of confounding with respect to the primary exposure variable, tobacco retailer density, for women residing within areas of high population density

		Tobacco Retailer Density	+ Deprivation	+ Deprivation + Marital Stat	+ Deprivation + Marital Stat + Income	+ Deprivation + Marital Stat + Income + Maternal Ed	+ Deprivation + Marital Stat + Income + Maternal Ed + Prenatal Care	+ Deprivation + Marital Stat + Income + Maternal Ed + Prenatal Care + Maternal Age	+ Deprivation + Marital Stat + Income + Maternal Ed + Prenatal Care + Depression
Relapsers	**Coefficient (β_{TR})**	0.0451	0.0129	0.0028	0.0036	0.0116	0.0136	0.0140	0.0158
	% Change in β_{TR}	n/a	-71.29	-78.08	26.56	223.21	17.61	2.80	16.03
Sustained Smokers	**Coefficient (β_{TR})**	0.0377	-0.0078	-0.0174	-0.0037	0.0055	0.0139	0.0147	0.0167
	% Change in β_{TR}	n/a	-120.64	123.28	-78.89	-251.17	150.10	5.85	20.36
Greatest Absolute % Change		n/a	120.64	123.28	78.89	251.17	150.10	5.85	20.36

β_{TR} equals coefficient of the Tobacco Retailer Density variable

Appendix B2: Model Building. Potential confounders for women residing in areas of low population density. Primary exposure variable, presence or absence of tobacco retailers. Change in coefficient of primary predictor following the addition of each covariate. Sustained Quitters were the referent group.

	Relapser		Sustained Smoker			
	Coefficient (Tobacco Pres/Abs)	Percent Change in Coefficient	Coefficient (Tobacco pres/abs)	Percent Change in Coefficient	Greatest Absolute % Change in Coefficient	Order to Enter Into Model
Tobacco Pres/Abs	-0.7803	n/a	-0.6774	n/a	n/a	n/a
+ Deprivation index	-0.6511	-16.56	-0.5436	-19.75	19.75	n/a
+ Marital Status	-0.8577	9.92	-0.7552	11.49	11.49	n/a
+ Income	-0.6695	-14.20	-0.5325	-21.39	21.39	3
+ Maternal Education	-0.8215	5.27	-0.7197	6.26	6.26	n/a
+ Trimester of Prenatal Care	-0.7990	2.40	-0.6851	1.15	2.40	n/a
+ Maternal Age	-0.8051	3.17	-0.6799	0.38	3.17	n/a
+ Depression	-0.9206	17.98	-0.6848	1.10	17.98	n/a
+ Cigarettes smoked before	-1.0681	36.87	-0.8843	30.56	36.87	2
+ Birth Order	-1.1495	47.31	-0.6854	1.19	47.31	1
+ Race/ethnicity	-0.7783	-0.26	-0.6724	-0.73	0.73	n/a
+ Residence w/ Smoker	-0.7311	-6.31	-0.6328	-6.58	6.58	n/a

Determination of confounding with respect to the primary exposure variable, presence or absence of tobacco retailers, for women residing within areas of low population density

		Tobacco outlets (Pres/Abs)	+ Birth Order	+ Birth Order + Cigs Before	+ Birth Order + Cigs Before + Income
Relapsers	**Coefficient (β_{TR})**	-0.7803	-1.1495	-1.5254	-1.5474
	% Change in β_{TR}	n/a	47.31	32.70	1.44
Sustained Smokers	**Coefficient (β_{TR})**	-0.6774	-0.6854	-1.0258	-1.0275
	% Change in β_{TR}	n/a	1.19	49.65	0.17
Greatest Absolute % change		n/a	47.31	49.65	1.44

β_{TR} equals coefficient of the Tobacco Retailer (presence or absence) variable

Appendix C

Test for linearity among log odds and continuous variables

Covariates	Stratum	Relapsers (p-value)	Scaling	Sustained Smokers (p-value)	Scaling
Tobacco Retailer Density	High Density	0.76	n/a	0.71	n/a
Maternal Age	High Density	0.81	n/a	0.33	n/a
	Low Density	0.77	n/a	0.27	n/a
Deprivation Index	High Density	0.84	n/a	0.32	n/a
	Low Density	0.24	n/a	0.38	n/a
Income	High Density	0.16	n/a	0.29	n/a
	Low Density	0.67	n/a	0.23	n/a

Sustained Quitters were the referent group. nlcheck test (nonlinearity test) performed, therefore, a value smaller than 0.05 suggests that the relationship is not linear.

Table 1. Sample characteristics of Portland area PRAMS participants, 2004-2007, with respect to smoking behaviors

	High Population Density (n=399)			Low Population Density (n=139)		
Maternal Characteristic	**Sustained Quitter**	**Relapser**	**Sustained Smoker**	**Sustained Quitter**	**Relapser**	**Sustained Smoker**
Count	131 (33%)	92 (23%)	176 (44%)	45 (32%)	30 (22%)	64 (46%)
Tobacco Retailers/10000 persons	8.0 (0.46)	9.0 (0.54)	9.0 (0.41)	---	---	---
Tobacco Outlets (%)						
Absent	9.2%	16.6%	8.2%	29.1%	47.3%	44.7%
Present	90.8%	83.5%	91.8%	70.9%	52.7%	55.3%
Reside with smoker?						
No	63.3%$^{\Psi}$	46%	34.2%	83.6%$^{\Psi}$	31.8%	36.8%
Yes	36.7%	54%	65.8%	16.4%	68.2%	63.2%
Age	27.7 (0.64)	25.4 (0.85)*	24.8 (0.91)*	27.8 (0.89)	25.2 (1.2)	27.5 (1.4)
Race/Ethnicity						
White, non-Hispanic	74.5%	81.4%	82.9%	91.9%	89.1%	85.3%
Non-white/Hispanic	25.5%	18.6%	17.1%	8.1%	10.9%	14.7%
Income	195.8 (20.9)	172.8 (21.6)	86.5 (8.0)*$^{\#}$	202.4 (27.3)	151.0 (31.5)	134.9 (19.1)*
Maternal Education						
Less than high school diploma	4.6%$^{\Psi}$	26.5%	21.1%	1.9%$^{\Psi}$	1.3%	20.8%
High school diploma	41.3%	31.9%	55.3%	64.9%	80.9%	48.7%
At least some college	54.1%	41.6%	23.7%	33.2%	17.8%	30.6%
Deprivation index	-0.22 (0.11)	0.065 (0.14)	0.14 (0.12)*	-0.39 (0.20)	-0.69 (0.31)	-0.69 (0.11)
Marital Status						
Married/Separated	65.8%$^{\Psi}$	27.0%	30.3%	73.6%$^{\Psi}$	45.7%	45.3%
Unmarried/Divorced/Annulled/NR	34.2%	73.0%	69.7%	26.4%	54.4%	54.7%
First prenatal care						
First Trimester	87.4%$^{\Psi}$	76.0%	61.3%	85.0%	67.0%	77.6%
Second or Third Trimester	12.6%	24.0%	38.7%	15.0%	33.0%	22.4%
Birth Order						
First birth	52.2%	40.7%	42.2%	35.3%	64.3%	29.7%
Second birth	23.6%	28.4%	32.9%	36.3%	27.6%	44.8%
Third or higher birth	24.2%	30.9%	24.9%	28.5%	8.1%	25.5%
Depression						
Sometimes/Rarely/Never	88.4%	84.2%	79.4%	80.8%	94.4%	79.3%
Always/Often	11.6%	15.8%	20.6%	19.2%	5.7%	20.7%
Average cigarettes smoked						
1 to 5	50.5%$^{\Psi}$	37.7%	15.5%	29.1%	11.9%	6.4%
6 to 10	17.3%	29.5%	30.1%	32.8%	36.7%	54.9%
11 to 41 or more	32.3%	32.8%	54.4%	38.2%	51.4%	38.7%

All values are weighted to account for the stratified systematic survey procedure. Continuous variables are reported as the mean with standard error. For continuous variables, paired t-tests were performed. p-values reported with respect to Sustained Quitter (*) $p < 0.05$, or Relapser (#) $p < 0.05$. Categorical variables were examined with Pearson Chi square tests. (Ψ) indicates $p < 0.05$ for the entire category with respect to either high or low population density residing participants. NR equals not reported.

Table 2. Bivariate associations of maternal characteristics with smoking behaviors of Portland area residing PRAMS participants, 2004-2007

	High Population Density (n=399)				Low Population Density (n=139)			
	Relapser		Sustained Smoker		Relapser		Sustained Smoker	
Maternal Characteristic	**Unadjusted Relative Risk Ratio (95% CI)**	**p**	**Unadjusted Relative Risk Ratio (95% CI)**	**p**	**Unadjusted Relative Risk Ratio (95% CI)**	**p**	**Unadjusted Relative Risk Ratio (95% CI)**	**p**
Tobacco Retailers/10,000 persons	1.05 (0.95, 1.15)	0.35	1.04 (0.97, 1.12)	0.31	n/a	n/a	n/a	n/a
Tobacco Retailers								
Absent	n/a	n/a	n/a	n/a	Reference	n/a	Reference	n/a
Present	n/a	n/a	n/a	n/a	0.46 (0.11, 1.89)	0.28	0.51 (0.15, 1.69)	0.27
Reside with smoker?								
No	Reference	n/a	Reference	n/a	Reference	n/a	Reference	n/a
Yes	2.02 (0.72, 5.72)	0.18	3.31 (1.36, 8.04)	0.01	10.92 (2.24. 53.33)	0.00	8.76 (2.23, 34.38)	0.00
Age	0.920 (0.848, 0.998)	0.045	0.899 (0.807, 1.00)	0.051	0.91 (0.79, 1.03)	0.15	0.99 (0.90, 1.09)	0.85
Race/Ethnicity								
White non-Hispanic	Reference	n/a	Reference	n/a	Reference	n/a	Reference	n/a
Non-white/Hispanic	0.67 (0.31, 1.44)	0.30	0.60 (0.32, 1.15)	0.12	1.38 (0.41, 4.63)	0.60	1.94 (0.70, 5.41)	0.20
Income	0.998 (0.994, 1.002)	0.44	0.989 (0.984, 0.993)	0.00	0.996 (0.990, 1.003)	0.25	0.995 (0.990, 1.00)	0.052
Maternal education								
Less than high school diploma	Reference	n/a	Reference	n/a	Reference	n/a	Reference	n/a
High school diploma	0.13 (0.04, 0.52)	0.00	0.29 (0.10, 0.91)	0.03	1.76 (0.24, 13.16)	0.58	0.07 (0.01, 0.40)	0.00
Some college or college degree	0.13 (0.04, 0.48)	0.00	0.10 (0.03, 0.29)	0.00	0.75 (0.079, 7.25)	0.81	0.08 (0.01, 0.54)	0.00
Deprivation Index	1.68 (0.88, 3.18)	0.11	1.92 (1.07, 3.45)	0.03	0.68 (0.24, 1.92)	0.46	0.68 (0.38, 1.20)	0.19
Marital Status								
Married/Separated	Reference	n/a	Reference	n/a	Reference	n/a	Reference	n/a
Unmarried/Divorced/Annulled/NR	5.20 (1.73, 15.65)	0.00	4.43 (1.82, 10.77)	0.00	3.32 (0.80, 13.85)	0.10	3.36 (1.01, 11.24)	0.049
First prenatal care								
First Trimester	Reference	n/a	Reference	n/a	Reference	n/a	Reference	n/a
Second or Third Trimester	2.19 (0.63, 7.58)	0.22	4.37 (1.51, 12.63)	0.01	2.79 (0.53, 14.58)	0.22	1.63 (0.36, 7.48)	0.53
Birth Order								
First birth	Reference	n/a	Reference	n/a	Reference	n/a	Reference	n/a
Second birth	1.54 (0.45, 5.33)	0.50	1.73 (0.62, 4.81)	0.30	0.42 (0.086, 2.03)	0.278	1.47 (0.38, 5.62)	0.58
Third or higher birth	1.63 (0.47, 5.67)	0.44	1.27 (0.44, 3.68)	0.66	0.16 (0.018, 1.34)	0.091	1.07 (0.241, 4.71)	0.93
Depression during pregnancy								
Sometimes/Rarely/Never	Reference	n/a	Reference	n/a	Reference	n/a	Reference	n/a
Always/Often	1.44 (0.40, 5.16)	0.58	1.98 (0.70, 5.57)	0.20	0.25 (0.055, 1.15)	0.08	1.09 (0.27, 4.49)	0.90
Average cigarettes smoked								
1 to 5	Reference	n/a	Reference	n/a	Reference	n/a	Reference	n/a
6 to 10	2.29 (0.63, 8.28)	0.21	5.68 (1.61, 20.04)	0.00	2.73 (0.42, 17.9)	0.30	7.63 (1.74, 33.48)	0.01
11 or more	1.4 (0.40, 4.59)	0.62	5.48 (1.79, 16.81)	0.00	3.29 (0.57, 19.12)	0.19	4.62 (1.06, 20.01)	0.04

All values are weighted to account for the stratified systematic survey procedure. CI equals confidence interval. p equals p-value. NR equals not reported. Sustained Quitters are the referent group for all associations.

Table 3. Multivariate associations of tobacco retailers with smoking behaviors of high population density residing Portland area PRAMS participants, 2004-2007

	Relapser		Sustained Smoker	
Maternal Characteristic	**Adjusted RRR (95% CI)**	**p-value**	**Adjusted RRR (95% CI)**	**p-value**
Tobacco Retailers/10,000 persons	1.02 (0.92, 1.12)	0.76	1.02 (0.92, 1.12)	0.75
Deprivation Index	1.23 (0.57, 2.64)	0.60	1.28 (0.64, 2.53)	0.49
Income	1.00 (0.997, 1.01)	0.35	0.992 (0.988, 0.996)	0.00
Marital Status				
Married/Separated	Reference	n/a	Reference	n/a
Unmarried/Divorced/Annulled/NR	4.87 (1.28, 18.57)	0.02	2.26 (0.77, 6.59)	0.14
Maternal education				
Less than high school diploma	Reference	n/a	Reference	n/a
High school diploma	0.21 (0.04, 1.18)	0.08	0.61 (0.18, 2.01)	0.41
Some college or college degree	0.20 (0.04, 1.08)	0.06	0.31 (0.08, 1.13)	0.08
First prenatal care				
First Trimester	Reference	n/a	Reference	n/a
Second or Third Trimester	1.78 (0.42, 7.55)	0.43	2.78 (0.85, 9.11)	0.09
Depression during pregnancy				
Sometimes/Rarely/Never	Reference	n/a	Reference	n/a
Always/Often	0.78 (0.21, 2.94)	0.72	0.74 (0.22, 2.46)	0.62

All values are weighted to account for the stratified systematic survey procedure. Adjusted RRR equals adjusted relative risk ratio. CI equals confidence interval. NR equals not reported. n=399. Sustained Quitters are the referent group for all associations.

Table 4. Multivariate associations of tobacco retailers with smoking behaviors of low population density residing Portland area PRAMS participants, 2004-2007

	Relapser		Sustained Smoker	
Maternal Characteristic	**Adjusted RRR (95% CI)**	**p-value**	**Adjusted RRR (95% CI)**	**p-value**
Tobacco Retailers				
Absent	Reference	n/a	Reference	n/a
Present	0.22 (0.05, 0.99)	0.048	0.36 (0.09, 1.44)	0.15
Birth Order				
First birth	Reference	n/a	Reference	n/a
Second birth	0.24 (0.04, 1.33)	0.10	0.86 (0.22, 3.32)	0.83
Third or higher birth	0.08 (0.01, 1.05)	0.06	0.55 (0.11, 2.69)	0.46
Average cigarettes smoked				
1 to 5	Reference	n/a	Reference	n/a
6 to 10	5.39 (0.55, 52.61)	0.15	10.04 (2.14, 47.02)	0.01
11 or more	7.15 (0.82, 62.40)	0.08	7.12 (1.44, 35.19)	0.02

All values are weighted to account for the stratified systematic survey procedure. Adjusted RRR equals adjusted relative risk ratio. CI equals confidence interval. NR equals not reported. n=139. Sustained Quitters are the referent group for all associations.