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Co-occurring obesity and smoking among U.S. women of reproductive age: Associations with educational attainment and health biomarkers and outcomes

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ABSTRACT

Introduction. Obesity and smoking are independently associated with socioeconomic disadvantage and adverse health effects in women of reproductive age and their children, but little is known about co-occurring obesity and smoking. The purpose of this study was to investigate relationships between co-occurring obesity and smoking, socioeconomic status, and health biomarkers and outcomes in a nationally representative sample.

Methods. Data from non-pregnant women of reproductive age were obtained from the U.S. National Health and Nutrition Examination Surveys reported between 2007 and 2010. Linear and logistic regressions were used to examine associations between obesity and smoking alone and in combination with educational attainment and a range of health biomarkers and outcomes.

Results. Prevalence of co-occurring obesity and smoking was 8.1% (~4.1 million U.S. women of reproductive age) and increased as an inverse function of educational attainment, with the least educated women being 11.6 times more likely to be obese smokers than the most educated. Compared to women with neither condition, obese smokers had significantly poorer cardiovascular and glycemic biomarker profiles, and higher rates of menstrual irregularity, hysterectomy, oophorectomy, physical limitations, and depression. Obese smokers also had significantly worse high-density lipoprotein (HDL) cholesterol levels, physical mobility, and depression scores than those with obesity or smoking alone.

Conclusions. Co-occurring obesity and smoking is highly associated with low educational attainment, a marker of socioeconomic disadvantage, and a broad range of adverse health biomarkers and outcomes. Interventions specifically targeting co-occurring obesity and smoking are likely necessary in efforts to reduce health disparities among disadvantaged women and their children.

Introduction

Obesity and smoking are the two leading causes of preventable morbidity and mortality in the U.S. and many other industrialized countries and independently linked to many of the same adverse outcomes in women, including reproductive health problems, heart disease, type-2 diabetes, cancer, impaired physical mobility, and depression (Abunassar et al., 2012; Hennekens and Andreotti, 2013; Jordan et al., 2006; LaCroix et al., 1993; Leitzmann et al., 2009; Østbye et al., 2002). Obesity and smoking are each overrepresented among socioeconomically disadvantaged women (May et al., 2013; Chilcoat, 2009; Wadden et al., 2002) and likely contributors to the unsettling trends towards increasing inverse associations between educational attainment and mortality risk among U.S. women (Montez and Zajacova, 2013).

While each condition is strongly associated with serious adverse health outcomes in women, relatively few studies have been reported on their co-occurrence. We know of only one prior study estimating prevalence of co-occurrence in a nationally representative sample of U.S. adult women in 2002, with prevalence estimated at 4.2% (Healton et al., 2006). Prevalence rates in women of reproductive age were not reported nor were relationships to health examined in that study. The few studies that are available examining associations with health suggest that co-occurring obesity and smoking poses greater risks

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than either alone, but much remains to be learned (Akbartabartoori et al., 2006). For example, answers to such basic questions as whether combined risks are additive or synergistic remain unclear. The only study we are aware of examining risks of co-occurring obesity and smoking on reproductive health was one that we reported examining breastfeeding rates in a clinical sample (Vurbic et al., 2014). The probability of breastfeeding varied in a graded additive manner, being lowest among those with co-occurring obesity and smoking, intermediate among those with obesity or smoking alone, and greatest among non-obese non-smokers (Vurbic et al., 2014). Considering the current U.S. and global obesity epidemic and that cigarette smoking prevalence in the U.S. is decreasing at a slower rate among women than men, these are not minor gaps.

The purpose of the present study was to begin learning more about the potential impact of co-occurring obesity and smoking on women's health. The present study used data from the National Health and Nutrition Examination Surveys (NHANES) to investigate U.S. prevalence rates, and associations with socioeconomic status, health biomarkers, and health outcomes associated with co-occurring obesity and smoking in women of reproductive age. We focused on educational attainment as a socioeconomic predictor because it is strongly linked to disparities in women's health (Higgins and Chilcoat, 2009; Meara et al., 2008). We examined associations between co-occurring obesity and smoking with cardiovascular and glycemic biomarkers to extend to women of reproductive age what has been observed on these health indicators in other populations (Akbartabartoori et al., 2006). We focused on gynecological/reproductive health outcomes, physical functioning, and depression because they are strongly associated with obesity and smoking alone, the impact of co-occurring obesity and smoking on these outcomes has not been previously reported, and these outcomes are of considerable importance to the health, economic, and social stability of women and their children.

Method

Data source and study sample

This study was conducted using data from the National Health and Nutrition Examination Survey (NHANES). NHANES is a continuous, nationally representative health survey of the U.S. civilian non-institutionalized population that uses a stratified multistage probability design and is reported in two-year cycles. We selected non-pregnant women between 25 and 49 years for whom there were data for lab-measured height and weight, and self-reported smoking status across two survey cycles, 2007–2008 and 2009–2010 to increase statistical power. The higher-than-usual lower age limit for women of reproductive age was chosen because setting the limit at age 25 increases the likelihood that women will have completed their education. We used a slightly higher-than-usual upper limit (49 vs. 44 years) to assure adequate sample sizes given the higher-than-usual lower limit. Educational attainment was selected to represent socioeconomic status because of its robust association with a wide range of health-related risk factors and outcomes (Cutler and Lleras-Muney, 2010). Strong associations between educational attainment and smoking in women have been widely reported (e.g., Higgins and Chilcoat, 2009), and associations with obesity in women have been reported as well including in previous reports using the NHANES (Ogden et al., 2010).

Each survey included a household interview and clinical examination. Demographic data and information regarding pregnancy and smoking status were collected during the former. Participants were classified as current smokers if they reported smoking ≥100 cigarettes lifetime and in the past 30 days. Height and weight were obtained during the physical examination. Obesity was defined as BMI (kg/m^2) ≥30.

Blood specimens were analyzed for cardiovascular (high-density lipoprotein [HDL] cholesterol, low-density lipoprotein [LDL] cholesterol, and triglyceride) and glycemic (blood glycohemoglobin [A1C], fasting plasma glucose, 2-h glucose [oral glucose tolerance test], and serum insulin) biomarkers (see Centers for Disease Control and Prevention, CDC, 2010). HDL cholesterol and glycohemoglobin levels, which do not require fasting, were available for the full sample while biomarkers that require fasting (e.g., triglycerides) were only collected in a randomly selected subset of participants.

Gynecological/reproductive health, physical functioning, and depression were assessed by questionnaires administered to the full sample. Gynecological/reproductive function was assessed by three items assessing whether women had (a) at least one menstrual period in the past 12 months (not including bleeding caused by medical conditions, hormone therapy, or surgery), (b) a hysterectomy (including partial removal of the uterus) or (c) bilateral oophorectomy (removal of both ovaries). Women who reported absence of a menstrual period related to pregnancy or breastfeeding were excluded from analyses of that item. Physical functioning was assessed using the validated and widely used physical functioning questionnaire (e.g., Vasquez et al., 2014), focusing on two items related to economic independence. The items inquired whether, as a result of a chronic health condition, respondents were limited in the work they were able to do or required use of special healthcare equipment. For depression, the validated Patient Health Questionnaire (PHQ-9; Martin et al., 2006) was used, which includes nine questions about frequency of depressive symptoms over the previous two weeks. Responses on each item correspond to a score ranging from 0 ("not at all") to 3 ("nearly every day"), which are added together to obtain a final score ranging from 0 to 27 and corresponding to mild (5–9), moderate (10–14), moderately severe (15–19), and severe depression (20–27).

Statistical methods

Simple statistical tests (t-tests and chi-squared) were used as a first look to compare socio-demographic characteristics across obese smokers, non-obese non-smokers, obese only, and smokers only. Associations between educational attainment (college graduates as the reference group) and being an obese smoker, smoker only, or obese only, each compared to all others, were tested using logistic regression. Linear regression was conducted to estimate average differences in continuous outcomes comparing each pairing of the indicator variables for obesity and smoking status. Similarly, logistic regression was conducted to estimate odds of binary outcomes comparing each pairing of indicator variables for obesity and smoking status. Looking into a possible interaction between smoking and obesity, linear and logistic regression models were tested with the main effects of smoking and obesity with a smoking by obesity interaction term. All regressions controlled for the potential confounding effects of age, education, race, and marital status.

Statistical software STATA version 12.1 was used for all analyses. The complex sampling design was taken into account by using the survey commands in STATA. NHANES provided weighting, stratum, and probability sampling unit variables that took into account unequal probabilities of selection resulting from the sample design, nonresponse, and planned oversampling of certain subgroups. Standard errors were computed using the jackknife repeated replication method, and weighted means, proportions, coefficients, odds ratios (ORs), and 95% confidence intervals (CIs) were reported. When comparing obese smokers vs. smokers only on two cholesterol (LDL cholesterol, triglyceride) and three glycemic (glycohemoglobin, fasting glucose, 2-hour fasting glucose) biomarkers, only the weighting and probability sampling unit designations were used. The stratum designation was not used due to only having one probability-sampling unit (minimum of two required) in one of the 31 strata. The unweighted sample sizes in these four models were all less than 400 individuals, resulting in the occurrence of a single probability-sampling unit when subjects were stratified into 31 groups. Excluding the stratum designation from our weighting procedure results in larger standard error, larger CIs, and, therefore, more conservative weighted effect estimates. Statistical significance was $p < .05$ in all analyses.

Results

Participant characteristics

Participants were 2477 non-pregnant women between the ages of 25–49 years, with 201 women in the obese smoker category, 406 in smokers only (smokers who are not obese), 644 in obese only (obese non-smokers), and 1226 in the neither obese nor smoker category. Among our weighted sample, 8.1% were obese smokers, representing 4,139,065 women in the US population, 16.4% were current smokers only, representing 8,323,895 women, 26.0% were obese only, representing 13,195,178 women, and the remaining 49.5% were neither obese nor smokers, representing 25,190,332 women, for a total