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The Impact of Smoking and Other Substance Use by Urban Women on the Birthweight of Their Infants

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ABSTRACT

The impact of maternal smoking and other substance use during pregnancy on infant birthweight is demonstrated in a sample of 766 urban women, using data collected in the Washington, D.C. Metropolitan Area Drug Study (DC*MADS). Women residing and giving birth in the District of Columbia were interviewed in 1992. A multivariable linear regression model was used to quantify the association between birthweight and the mother's use of cigarettes, alcohol, or illicit drugs during pregnancy, while controlling for possible confounding variables. The analysis focused on factors,

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including prenatal care and substance use during pregnancy that may contribute to low birthweight infants born to this sample of urban, predominantly black women. A woman's use of cigarettes, marijuana, and heroin during pregnancy was related to infant birthweight, but her use of alcohol and cocaine during pregnancy was not significantly related. Smoking during pregnancy was a strong predictor for low birthweight, suggesting that targeting more smoking cessation programs for pregnant women, particularly those who may also be illicit drug users, could help reduce adverse health consequences for low birthweight infants.

Key Words: Tobacco; Smoking; Pregancy; Low birthweight; Prenatal substance use.

INTRODUCTION

This study builds on previous research about the effects of substance use, and particularly tobacco use, by pregnant women on the birthweight of their infants. Maternal substance use has been studied in a number of different subpopulations using a variety of methodologies (Pollack, 2001; Shiono et al., 1995; Shu et al., 1995). The results of this study relate specifically to a low-income, predominantly black population of urban women who were interviewed as part of the Washington, D.C., Metropolitan Area Drug Study (DC*MADS). DC*MADS was a large integrated study that examined the magnitude of drug use and its effects in an urban area. The study was sponsored by the National Institute on Drug Abuse (NIDA) to address the alarming trend in drug abuse in major U.S. cities. Washington, D.C. was chosen as the site for this comprehensive study because of the magnitude and visibility of the impact of drug abuse on our nation's capitol. The study was designed to serve as a prototype for related studies in other large metropolitan areas.

The DC*MADS substudy described here focused on women's illicit drug use during pregnancy. The D.C. population has a large low-income population, and drug use is higher than in some other urban areas (Bray et al., 1999). Because of this population characteristic and the sampling technique used to select the women for DC*MADS, illicit-drug-using women were overrepresented in the sample. Thus, these data offered a unique opportunity to study not only a high risk population of pregnant women, but also to determine the effects of maternal smoking and the use of other substances during pregnancy on infant birthweight. We were also able to explore factors related to smoking and low birthweight (defined as < 2500 grams) that may be peculiar to low-income and

drug-using women, which may in turn inform policies directed at this group.

Although pregnant women should be encouraged to refrain from using illicit drugs while pregnant, recent studies indicate that the use of illicit drugs—particularly cocaine—may not affect birthweight or other developmental indicators as much as previously believed. The recently completed Maternal Lifestyle Study studied cocaine and other drug use during pregnancy among women in four study sites (Bauer et al., 2002; Lester et al., 2001). This study, which obtained maternal self-reports of drug use as well as meconium samples from 8527 newborns, found that low birthweight infants had a higher prevalence of cocaine exposure (18.6% for very low birthweight infants and 21.1% for low birthweight infants, compared to 10.7% overall). However, a systematic review of research on this topic found no consistent negative association between a woman's use of cocaine during pregnancy and her infant's physical growth, developmental test scores, or receptive or expressive language development (Frank et al., 2001). The same review suggested that many of the negative effects once attributed to prenatal cocaine exposure are at least partially attributable to prenatal exposure to tobacco. For example, in a prospective, multicenter study of 7470 women, neither cocaine use or marijuana use during pregnancy was related to low birthweight (Shiono et al., 1995). However, cigarette smoking was positively related to low birthweight in this study (odds ratio [OR]: 1.5; 95% confidence interval [CI]: 1.2, 1.8).

Other research studies have also demonstrated that smoking during pregnancy increases the risk for low birthweight. In a case-control study of white and black women, mothers of small-for-gestational-age infants were significantly more likely to be cigarette smokers than mothers of normal weight infants (Sprauve et al., 1999). This result was found for both races, and a dose-response relationship between birthweight and the number of cigarettes smoked during pregnancy was observed. Another study found that even reducing the number of cigarettes smoked during pregnancy is associated with some birthweight gains (Secker-Walker et al., 1998). In this observational study of more than 600 women, infants whose mothers reduced their cigarette consumption by 10 cigarettes per day after the first prenatal visit had an estimated birthweight gain of 105 grams compared with infants whose mothers smoked 20 cigarettes per day throughout their pregnancy. In a recently completed case-control study of 741 mothers, maternal smoking was defined as never smoked (did not smoke during the three months prior to pregnancy or during pregnancy), quit (only smoked during prepregnancy or during the first trimester), or continuous (smoked continuously from prepregnancy to

delivery). Continuous smoking was associated with a reduction in mean birthweight of 377 grams, compared to never smoking, in this study (Wang et al., 2002).

Maternal weight and weight gain are important factors in infant birthweight (Abrams and Laros, 1986; Luke, 1994). Smoking, however, appears to increase the risk for lower birthweight babies, regardless of whether the pregnant woman is obese or of normal weight. In a retrospective study of more than 1300 women, smoking was associated with the delivery of lower birthweight infants for both obese and normal weight women, and weight gain during pregnancy did not eliminate the birthweight-lowering effects of smoking (Hellerstedt et al., 1997). Another study found that the deleterious effects of cigarette smoking were even more pronounced for smaller infants, such as twins (Pollack et al., 2000). This study controlled for possible confounding variables, such as maternal age, race, Hispanic ethnicity, education, trimester of prenatal care initiation, and infant gender.

In 1999, an estimated 17% of pregnant women between the ages of 15 and 44 smoked tobacco in the past month, based on results from the National Household Survey on Drug Abuse (Substance Abuse and Mental Health Services Administration, 2001). Although this percentage is lower than among nonpregnant women, it has been suggested that smoking by pregnant women is responsible for 15% of all preterm births, 20–30% of all infants of low birthweight, and a striking 150% increase in overall perinatal mortality (Andres and Day, 2000). Recent statistics based on U.S. birth certificate information indicate that the percentage of low birthweight infants is 12.1% for smokers compared with 7.2% for nonsmokers (Matthews, 2001). In a randomized intervention trial that included 1146 low-income black women, cigarette smoking was associated with both low birthweight and preterm births (Moore and Zaccaro, 2000). When compared with nonsmokers, light smokers (less than half a pack per day) in this study were almost twice as likely, and heavy smokers (at least half a pack per day) were three times more likely, to have low birthweight infants (ORs = 1.89 and 3.03, respectively).

Any factor that increases the rate of low birthweight is of special importance for black women, who are more likely to deliver low birthweight babies than women of other races. The National Center for Health Statistics (NCHS) reported that 13.0% of babies born to black women were low birthweight compared with only 6.3% of babies born to white women (National Center for Health Statistics, 1998). In a study of low-income pregnant women, the proportion of low birthweight births was 10.3% for blacks and 6.1% for nonHispanic whites (Barnett, 1995). A study of 1491 women found that black women were more likely than

white women to have low birthweight, preterm, and growth-restricted babies (Goldenberg et al., 1996). In both of these studies, the race differential in birthweight was found even though more of the white mothers smoked during their pregnancies than did the black mothers. In fact, smoking during pregnancy is more prevalent among white women (15.7%) than among black women (9.1%) in the United States (Matthews, 2001). This suggests that black infants may be more susceptible to the birthweight-lowering effects of in utero tobacco exposure than white infants.

Low birthweight is a leading risk factor for neonatal and infant mortality in the United States (Singh and Yu, 1995). It has been associated with intrauterine growth retardation, which causes these children during childhood growth to remain significantly lighter in weight and shorter in height than their counterparts (Strauss, 1997). Low birthweight infants may also be at an elevated risk for later chronic disease, developmental deficits, and cognitive impairment (Schendel et al., 1997). In a prospective study involving two previously studied cohorts, school-aged children who had been born at low birthweight had poorer overall mental and emotional well-being based on several standardized measures of assessment (McCormick et al., 1996). In an 18-year followup study of 1265 children, those who were exposed to maternal smoking were more likely to show psychiatric symptoms in adolescence, such as substance abuse and depression (Fergusson et al., 1998).

Thus, low birthweight can confer significant consequences on children. These health and developmental effects may be magnified by other conditions faced by urban black children, such as low-income households and lack of access to medical care. Despite the observed relationships in other research on the impact of smoking and other substance use on low birthweight, few studies have examined the use of the full range of substances, especially among urban black women. Because this group is at higher risk for low birthweight, it is valuable to understand the factors that contribute to the effect of smoking on the occurrence of low birthweight in this high-risk group. This study investigated associations between demographic, maternal, and infant factors and the birthweight of infants born to a sample of urban, predominantly black women. The impact of smoking and other substance use during pregnancy on birthweight was examined, after controlling for known risk factors and possible confounders.

METHODS

The data analyzed for this study were collected as part of DC*MADS, which assessed the extent of illicit drug, alcohol, and

cigarette use in a number of D.C. metropolitan area subpopulations (Bray and Marsden, 1999). DC*MADS was conducted from 1989 to 1995 and included surveys of populations not generally represented in national surveys, such as juvenile offenders, homeless and transient people, institutionalized persons, those currently in substance abuse treatment, and pregnant women. The data used for the current study were collected in the DC*MADS Drug Use and Pregnancy Study, a survey of women giving birth in Washington, D.C. hospitals. The design and methods employed in the DC*MADS pregnancy study have been described elsewhere (National Institute on Drug Abuse, 1995; Visscher et al., 1999).

In this section, we briefly review the methods used to collect data in the DC*MADS pregnancy study, then describe our analytic approach for exploring these data. The dependent variable for our analysis was infant birthweight. The analysis focused on factors, including prenatal care and substance use during pregnancy that may contribute to low birthweight infants born to this sample of urban women. Descriptive statistics were used to characterize the sample. A multivariable linear regression model was used to quantify the association between birthweight and the mother's use of cigarettes, alcohol, or illicit drugs during pregnancy, while controlling for possible confounding variables.

Data Collection

The DC*MADS pregnancy study was conducted in 1992 at eight participating hospitals in Washington, D.C. Women who had just given birth at these hospitals were selected and asked to participate in the study. During in-person interviews, each woman was asked to report her cigarette, alcohol, and illicit drug use during pregnancy; pregnancy history; and attitudes toward pregnancy. Infant birthweight was obtained from hospital logs. In addition, if the woman agreed, her medical records and those of her infant were abstracted to collect information about maternal and infant outcomes and complications.

The study used a two-stage stratified sampling design, with hospitals selected in the first stage and the women and their infants selected in the second stage. The sampling frame included hospitals in the Washington, D.C. metropolitan area (which included hospitals in Washington, D.C. as well as in Maryland and Virginia) with birthing and delivery facilities taken from a full national listing of hospitals (American Health Association, 1990). A special advisory group, comprised of local hospital administrators, physicians, nurses, and public health professionals, was

formed to advise research staff on the best way to gain participation from the selected hospitals. Informational materials were developed, then meetings were requested with key staff at each hospital. The main tasks requested of the hospital staff were to obtain approval for the study from their Institutional Review Board (IRB), then to handle logistical issues related to both interviews and abstractions once the study was underway. All sampling and data collection tasks were done by study staff. Barriers to gaining participation in the hospitals included facilitation of the IRB approval process, obtaining the support of key hospital staff, and convincing the hospitals of the importance of the study and that they would benefit from the findings. All nine eligible hospitals in Washington, D.C. were selected for the sample, of which eight agreed to participate. All eight of these hospitals agreed to participate in both the interviewing and the record abstraction components of the study.

The second stage of sampling involved selecting mothers for an interview from within the selected hospitals. Women with low birthweight (< 2500 grams) or preterm (< 37-week gestation) infants were oversampled to maximize the number of women at risk for substance abuse in the sample (Visscher et al., 1999). On randomly chosen days, the interviewers contacted each participating hospital to determine whether any live births occurred on the previous day. Using a standard algorithm, the interviewer randomly selected women from among all women who had given birth to live infants within the preceding 24-hour period. Because several hospitals (particularly those in Maryland and Virginia) did not grant access to some of their non-D.C. resident patients (those with private insurance), only D.C.-resident women who gave birth at the participating Washington, D.C. hospitals were included in this analysis.

Once all necessary IRB approvals were obtained, data collection began at the hospitals. Interviews and record abstractions were completed by trained data collectors. The interviewers for the study, who selected the women and conducted the in-person interviews, were selected based on their prior experience working with pregnant women, in hospitals, or with at-risk populations. The interviewing staff was all female and included nurses, family counselors, hospital administrative staff, and operators of homeless shelters. After confirming with the charge nurse or physician that a woman was medically able to be interviewed, the interviewer approached the woman in her hospital room and explained the study. If the woman was interested, the interviewer administered informed consent. This process involved going over all aspects of the informed consent form, including the purpose of the study, types of

questions to be asked, how confidentiality would be maintained, and the fact that participation was totally voluntary. The woman was informed that the study had a federal Certificate of Confidentiality, which further protected the study information and their identities. If the woman agreed, the interviewer signed the consent form to further ensure the woman's confidentiality and the interview setting was made as private as possible. The majority of the survey questions were asked by the interviewer who recorded the respondent's answers in an interview booklet. The questions concerning the use of illicit drugs, alcohol, and cigarettes were self-administered to further ensure respondent confidentiality and promote truthful responses. The woman's name did not appear anywhere on the questionnaire and the completed questionnaire and answer sheets were sealed into an envelope and mailed directly to the field office. Each woman who completed the personal interview was asked to give her permission for research staff to access her medical record and that of her infant. The women were offered a small baby gift (a layette or towel set, with a monetary value of $10) in appreciation for their participation in the interview, and $5 in cash if they also gave permission for the medical records abstraction.

A total of 883 D.C.-resident women were invited to participate in the study. Of these, 766 women agreed to participate in the interview and 527 also granted permission for medical record abstraction. Thus, the cooperation rates for the interview and abstraction components of the study were 86.7% and 68.8%, respectively.

Analytic Approach

Our analytic approach centered on the hypothesis that smoking is a major contributor to infant birthweight, even after controlling for the effects of known risk factors for low birthweight and use of alcohol and illicit drugs. Descriptive statistics were used to characterize the sample in terms of sociodemographic, pregnancy-related (e.g., mother's weight gain during pregnancy, gestational age of the infant, and prenatal care), and substance use data that were obtained through the in-person interviews. We used chi-square test statistics to compare these variables for women with normal birthweight infants (≥ 2500 grams) and women with low birthweight infants (< 2500 grams). A multivariable linear regression model was used to explore the association between smoking and birthweight (as a continuous variable) while controlling for possible confounding variables. The estimated regression coefficients from the linear regression analysis yielded estimates for the grams of birthweight

change attributed to each variable in the model. *T*-test statistics were used to test hypotheses.

In developing our regression model, we relied on previous research to determine which variables to enter. We also reviewed the descriptive statistics and examined those variables that appeared to be most strongly associated with low birthweight. Drawing on research at the Institute of Medicine (1985), we entered the following into our statistical models: age, race, marital status, income, number of prenatal visits, parity, twin status, infant gestational age, mother's weight before pregnancy and weight gain during pregnancy, parity (number of previous live births), substance use during pregnancy, diabetes, and hypertension. SUDAAN (SUrvey DAta ANalysis) statistical software was used in the statistical analysis to account for the stratified sample design (Shah et al., 1994).

Finally, we fit a linear regression model that reflected previous research and our descriptive statistics. The model had a number of covariates—race, number of prenatal visits, mother's prepregnancy weight and weight gain during pregnancy, mother's height, twin status, and infant gestational age—along with substance use during pregnancy. The substance use variables were alcohol, cigarettes, and the illicit drugs with the highest prevalence: marijuana, cocaine, and heroin. The coding scheme for the variables used to fit the model is shown in Table 1.

The dependent variable in our analysis was infant birthweight in grams, which was treated as a continuous variable in the linear regression model. Other continuous variables were the number of prenatal visits, the mother's weight and weight gain (in pounds), the mother's height (in inches), and the infant's gestational age (in weeks). The variables used for race and twin status were coded as shown in Table 1. Data for substance use during pregnancy (i.e., alcohol, cigarettes, and illicit drugs) were self-reports from the surveys. If a woman reported using a specific substance during pregnancy, the variable was coded 1; it was coded 0 if she did not. Crack cocaine and intranasal cocaine were collapsed into a single dichotomous variable labeled "cocaine." This cocaine variable captured the use of any form of cocaine during pregnancy, including powder and freebase cocaine.

Imputation and Weights

A total of 786 data records were available for analysis, representing the infants born to the 766 participating mothers (20 mothers had twins).

Table 1. Coding scheme used in the linear regression analysis.

Variable	Description
Black race	1 = Black
	0 = White, Hispanic, other
Hispanic race	1 = Hispanic
	0 = White, black, other
Prenatal visits	Count (number of visits)
Mother's weight before pregnancy	Continuous (in pounds)
Mother's weight gain during pregnancy	Continuous (in pounds)
Mother's height	Continuous (in inches)
Twin status	1 = Birth did include twins
	0 = Birth did not include twins (singleton birth)
Infant gestational age	Continuous (in weeks)
Cigarette use	1 = Cigarette use during pregnancy
	0 = No cigarette use during pregnancy
Alcohol use	1 = Alcohol use during pregnancy
	0 = No alcohol use during pregnancy
Marijuana use	1 = Marijuana use during pregnancy
	0 = No marijuana use during pregnancy
Cocaine use	1 = Cocaine/crack use during pregnancy
	0 = No cocaine/crack use during pregnancy
Heroin use	1 = Heroin use during pregnancy
	0 = No heroin use during pregnancy
Infant birthweight	Continuous (in grams)

Imputation was conducted for some explanatory variables so that information from fewer data records would be lost in the analysis due to missing data. Overall, 31 of the 786 records were excluded from the analysis, and 143 records had some imputed values. The excluded records included two where the dependent variable (birthweight in grams) was missing, five records that were missing race, and 24 that were missing gestational age. For one record missing the diabetes variable, its value was imputed to be the mean for its race and age. For two records missing the maternal age variable, these values were imputed as the mean age for their race and parity. Parity, missing for 10 records, was imputed to be the mean for their race and age. Mother's height, missing for six records, was imputed to be the mean height for the mother's weight before pregnancy. Likewise, mother's weight before pregnancy, which was missing for 13 records, was imputed to be the mean weight for the mother's height

before pregnancy. Mothers' weight gain during pregnancy, missing for 20 records, was imputed to be the mean weight gain for the gestational age of the infant. For 20 records that were missing marijuana use during pregnancy, these values were imputed to be the mean for their race. The variable for heroin use during pregnancy had 33 missing records; these were imputed to be the mean for their race and age. The variable for the number of prenatal care visits had 77 missing records. For the records that did not have missing values for trimester of initial prenatal care, the number of visits was regressed on trimester to impute values. When both the number of prenatal visits and trimester were missing, the number of visits was regressed on the variables for cocaine use and attitudes toward pregnancy to impute values because these two variables were significant covariates in a previous model of trimester of initial prenatal care.

Weight trimming was used to reduce the possibility of a single observation having high influence on the model. The analytic weights in the dataset ranged from 3.07 to 67.54. A total of 13 records had a 67.54 analytic weight, two had weights in the range from 40 to 42, and 20 had weights equal to 30.14. The remaining records had weights < 25. Therefore, to reduce the leverage of records with high weights, the analytic weights for those records were trimmed down to 25.

RESULTS

Description of the Sample

Most women in this study were young, single, minority females who were receiving some form of public assistance. An estimated 49.9%, or half of the study population, was between the ages of 18 and 25. Many were of racial/ethnic minorities: 83.9% were black and 7.5% were Hispanic (based on self-defined race or answer to ethnicity question "Are you of Hispanic or Spanish origin or descent?"). Almost three-quarters (72.3%) had at least a high school education. Most (73.7%) were single at the time of delivery, and only 22.8% were married. More than half (63.8%) of the women lived in households with a total annual income of $\leq$ \$19,000, and almost one-fifth (19.3%) lived in households with an annual income of $<$ \$5,000. For 69.0% of the sample, Medicaid was the expected source of payment for the delivery and hospitalization. About one third of the women had two or more previous livebirths. A large majority (87.8%) of the women in the sample received at least

some prenatal care during their first or second trimester, but the remaining 12.2% of women received only late prenatal care (first visit in third trimester), or none at all.

Maternal Characteristics and Infant Birthweight

An estimated 12.8% of the D.C. women in the study population had infants born at low birthweight, defined as a weight of <2500 grams (5 pounds, 8 ounces). Table 2 compares the characteristics of women with normal birthweight infants (≥ 2500 grams) with those of women with low birthweight infants (<2500 grams). Chi-square statistics with their associated *p*-values are shown to demonstrate statistically significant differences. More women with low birthweight infants were either very young (12–17 years) or older (at least 35 years old) ($\chi^2 = 9.75$; 3 *df*; $p < 0.0214$). Black women were more likely than white or Hispanic women to have low birthweight infants ($\chi^2 = 28.58$; 3 *df*; $p < 0.0001$). Education was also strongly associated with birthweight. Women with normal birthweight infants were more likely to have completed some college or have graduated from college ($\chi^2 = 21.32$; 3 *df*; $p < 0.0001$). Household income and marital status, moreover, were significantly associated with the infant birthweight. Women with low birthweight infants were more likely to have annual household incomes of $\leq$\$19,000 ($\chi^2 = 26.35$; 1 *df*; $p < 0.0001$) and to be single ($\chi^2 = 16.12$; 2 *df*; $p < 0.0003$).

Mothers of normal and low birthweight infants also differed in terms of physical characteristics and pregnancy-related factors. Women who gave birth to normal weight infants had a tendency to weigh more before pregnancy and to gain more weight during pregnancy ($\chi^2 = 11.08$; 1 *df*; $p < 0.0009$). Women with normal birthweight infants were also taller than women with low birthweight infants ($\chi^2 = 6.81$; 1 *df*; $p < 0.0092$). Having diabetes during pregnancy did not significantly affect a woman's chance of having a low or normal weight infant, but women with low birthweight infants were more likely to have had more previous livebirths. The timing and amount of prenatal care were strongly associated with infant birthweight. Women with normal weight infants were more likely to initiate prenatal care during their first trimester and to have more total prenatal visits during the pregnancy. As expected, more low birthweight infants were born preterm (<37 weeks gestation), and this was highly statistically significant ($\chi^2 = 134.71$; 1 *df*; $p < 0.0001$). Twin births were also more common among the women with low birthweight infants.


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Substance Use and Infant Birthweight

Cocaine was the illicit drug most commonly used by women delivering at D.C. hospitals. An estimated 10.5% of new mothers reported using cocaine (usually crack cocaine) during their pregnancy. Other drugs were reported less often by these women during their pregnancy: 7.1% reported using marijuana/hashish, and 1.4% reported using heroin. More of the women used cigarettes or alcohol during their pregnancies: 22.5% reported smoking cigarettes, and 21.1% reported using alcohol during their pregnancy. Although the majority of the women did not use any substances, including cigarettes or alcohol, the women showed use of various combinations of substances. Figure 1a shows the distribution of cigarette and alcohol use. Two thirds (66.8%) of the women did not use either cigarettes or alcohol during their pregnancies. The remaining women were fairly evenly divided between those who used cigarettes only (11.1%), alcohol only (9.4%), and both cigarettes and alcohol (12.7%). Figure 1b shows, for groups of women who used cigarettes and/or alcohol, the use of illicit drugs during pregnancy (group 1 = neither cigarettes nor alcohol, group 2 = cigarettes only, group 3 = alcohol only, and group 4 = both cigarettes and alcohol). Note that polydrug use was common: A large percentage (32.2%) of women who smoked during pregnancy also used at least one illicit drug. This finding was particularly striking for those women who reported that they both smoked cigarettes and drank alcohol during pregnancy: over half (56.4%) of these women also used at least one illicit drug. Considerably fewer of the women who used alcohol but not cigarettes, or who used neither alcohol nor cigarettes, also used illicit drugs during their pregnancy (12.2% and 3.2%, respectively).

Table 3 presents data on the association between substance use and infant birthweight. Women with low birthweight infants were more than twice as likely to smoke cigarettes during pregnancy ($\chi^2 = 32.7$; 1 *df*; $p < 0.0001$) than women with normal weight infants. This was also true for cocaine: Mothers of low birthweight infants reported using cocaine during their pregnancy more than twice as often as did mothers of normal weight infants ($\chi^2 = 15.2$; 1 *df*; $p < 0.0001$). The mothers of low birthweight infants were also more likely than women of normal weight infants to use alcohol, although the difference was not as striking as for cigarettes or cocaine. There was also a tendency, although not statistically significant, for women giving birth to low birthweight infants to report more heroin or marijuana use during pregnancy than other mothers.

Table 2. Characteristics of women with normal and low birth weight infants.

Variable	Description	Women with normal birthweight infants (≥2500 g)	Women with low birthweight infants (< 2500 g)	Chi-square	*p*-value	*df*
Age in years	12–17	3.8	7.4	9.75	0.0214	3
	18–25	48.9	43.0			
	26–34	36.7	30.2			
	35 or older	10.6	19.5			
Race	White	8.1	1.3	28.58	< 0.0001	3
	Black	82.9	94.3			
	Hispanic	7.7	4.1			
	Other	1.4	0.4			
Education	< 4 years of high school	28.0	29.5	21.32	0.0001	3
	High school graduate	42.6	55.4			
	Some college	15.1	9.9			
	College graduate	14.3	5.2			
Annual income	≤ $19,000	63.1	73.9	26.35	0.0001	1
	> $19,000	37.0	26.2			
Marital status	Single	72.1	83.3	16.12	0.0003	2
	Married	24.5	11.7			
	Divorced or separated	3.4	5.0			
Mother's weight before pregnancy	< 140 pounds	56.5	65.0	3.31	0.0692	1
	≥140 pounds	43.5	35.0			

Mother's weight gain during pregnancy	<28 pounds	44.9	61.2	11.08	0.0009	1
	≥28 pounds	55.1	38.8			
Mother's height	<64 inches	34.8	47.6	6.81	0.0092	1
	≥ 64 inches	65.2	52.4			
Maternal diabetes	Had diabetes	5.9	7.0	0.13	0.7171	1
	No diabetes	94.1	93.0			
Parity	No previous livebirths	32.7	31.0	8.19	0.0170	2
	One previous livebirth	34.0	23.7			
	Two or more livebirths	33.3	45.4			
Trimester of first prenatal care	First	56.2	43.3	9.02	0.0113	2
	Second	28.3	32.8			
	Third or none	15.5	24.0			
Number of prenatal visits	<11 visits	37.9	65.4	27.66	<0.0001	1
	≥11 visits	62.1	34.7			
Infant's gestational age	<37 weeks (preterm)	6.2	60.6	134.71	<0.0001	1
	≥37 weeks (term)	93.8	39.4			
Twin status	Twin birth	2.3	15.4	15.69	0.0001	1
	Singleton birth	97.7	84.6			

Note: Percentages are weighted estimates based on 766 sampled women and 786 infants (includes 20 sets of twins).

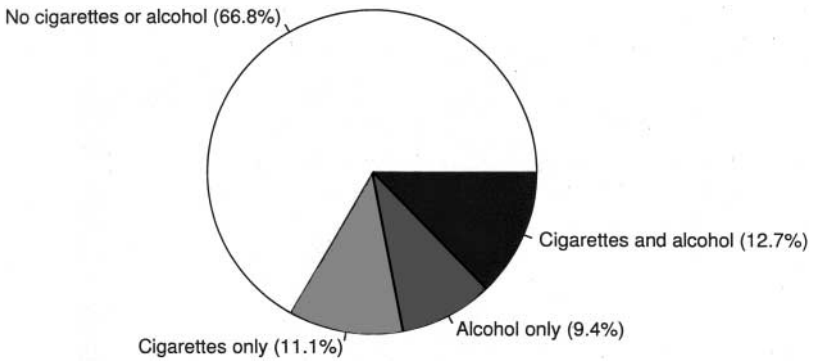

Figure 1a. Use of cigarettes and alcohol during pregnancy.

Linear Regression Analysis of Infant Birthweight

We developed a linear regression model to examine associations between infant birthweight and other factors in this sample of urban women. Birthweight (in grams) was entered as the dependent variable in the model. Independent variables, including known risk factors for low birthweight and possible confounders, were then added to the model. These variables included various demographic, maternal, and infant characteristics, as well as the variables for substance use during pregnancy. Several variables were dropped from the final model because they were not significant predictors of birthweight, including mother's age, diabetes, and hypertension. Alcohol use and cocaine use during pregnancy were also eliminated from the final model because they showed no significant relationship to infant birthweight in the model.

Table 4 presents the results of our final multivariable linear regression model. The model predicted infant birthweight, based on the independent variables in the model. Minority race was related to infant birthweight. The predicted birthweights for black and Hispanic infants were 207.03 grams less ($p = 0.0002$) and 89.82 grams less (not statistically significant), respectively, than for white infants.

Figure 2 depicts the difference in birthweight for black and nonblack infants, by smoking status of the mother. As shown on this box plot, the difference in birthweight by race is evident for both smokers and nonsmokers (when the notches on a box plot do not overlap, the medians are significantly different at the 5% level).

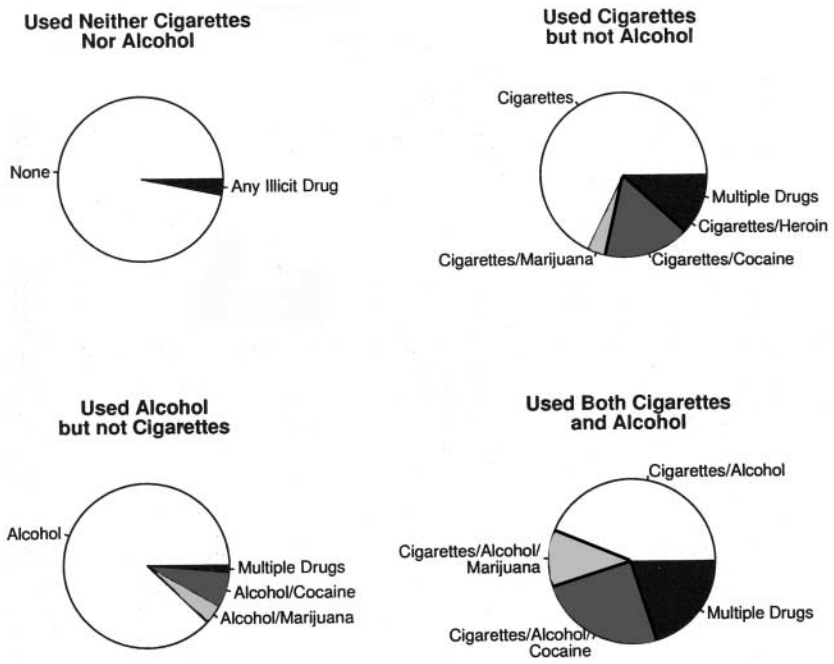

Figure 1b. Use of illicit drugs during pregnancy, by cigarette/alcohol use.

Prenatal care also affected birthweight, with each additional visit adding over 9 grams to the infant's predicted weight (see Table 4). Both the mother's weight before pregnancy and her weight gain during pregnancy had an effect on the infant's weight, adding 2.20 and 4.98 grams, respectively, to the infant's predicted weight for each pound of the mother's weight or weight gain. Each inch of the mother's height added 19.02 grams to the infant's predicted birthweight. Twins were 518.32 grams lighter, on average, than singleton babies. Each additional week of gestation added 137.69 grams to the infant's predicted weight.

Figure 3 shows infant birthweight for infants born at term (≥ 37 weeks gestation) or preterm (< 37 weeks gestation), by smoking status of the mother. The effect of smoking on lowering birthweight can be seen on this box plot for both term and preterm nonsmokers (when the notches on a box plot do not overlap, the medians are significantly different at the 5% level).

Results for substance use revealed that heroin use had the largest effect on predicted birthweight. The infants of heroin users

Table 3. Substance use during pregnancy, by women with normal and low birthweight infants.

Variable	Women with normal birthweight infants (≥2500 g)	Women with low birthweight infants (<2500 g)	Chi-square	*p*-value	*df*
Used cigarettes during pregnancy	20.4	46.4	32.7	<0.0001	1
Used alcohol during pregnancy	20.5	32.1	9.7	0.0019	1
Used cocaine/crack during pregnancy	9.0	21.6	15.2	0	1
Used marijuana during pregnancy	5.9	10.2	2.9	0.0877	1
Used heroin during pregnancy	1.0	5.1	3.6	0.0594	1

Note: Percentages are weighted estimates based on 766 sampled women and 786 infants (includes 20 sets of twins).

Table 4. Linear regression model for correlates of infant birthweight.

Correlate	Variables	Beta coefficient	SE beta	*T*-test (beta = 0)	*p*-value
Intercept		−3,734.54	496.99	−7.51	< 0.0001
Demographics	Black	−207.03	54.58	−3.79	0.0002
	Hispanic	−89.82	90.17	−1.00	0.3195
Prenatal care	Number of prenatal visits	9.87	5.15	1.91	0.0560
Maternal characteristics	Weight before pregnancy (pounds)	2.20	0.62	3.54	0.0004
	Weight gain during pregnancy (pounds)	4.98	1.78	2.80	0.0053
	Height (inches)	19.02	7.46	2.55	0.0110
Infant characteristics	Twin	−518.32	67.45	−7.68	< 0.0001
	Gestational age (weeks)	137.69	6.15	22.38	< 0.0001
Substance use during pregnancy	Marijuana	139.36	68.49	2.03	0.0422
	Heroin	−450.05	118.71	−3.79	0.0002
	Cigarettes	−130.90	47.33	−2.77	0.0058

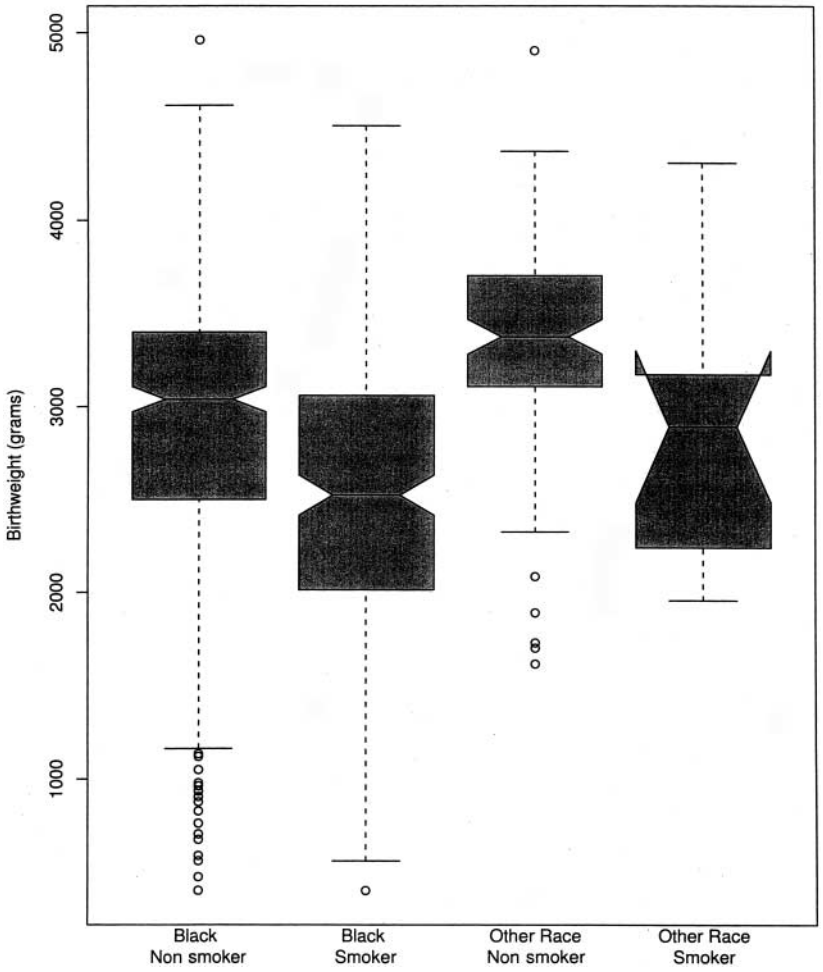

Figure 2. Birthweight distribution, by race and smoking status.

were 450.05 grams lighter than those of women who did not use heroin. Smokers had infants whose predicted birthweights were 130.90 grams lighter than those of nonsmokers. In contrast to heroin use, smoking during pregnancy was very common in these women, and therefore affected the birthweights of many infants. Curiously, the predicted birthweight for infants of marijuana users was 139.36 grams *heavier* than infants of women who did not use marijuana.

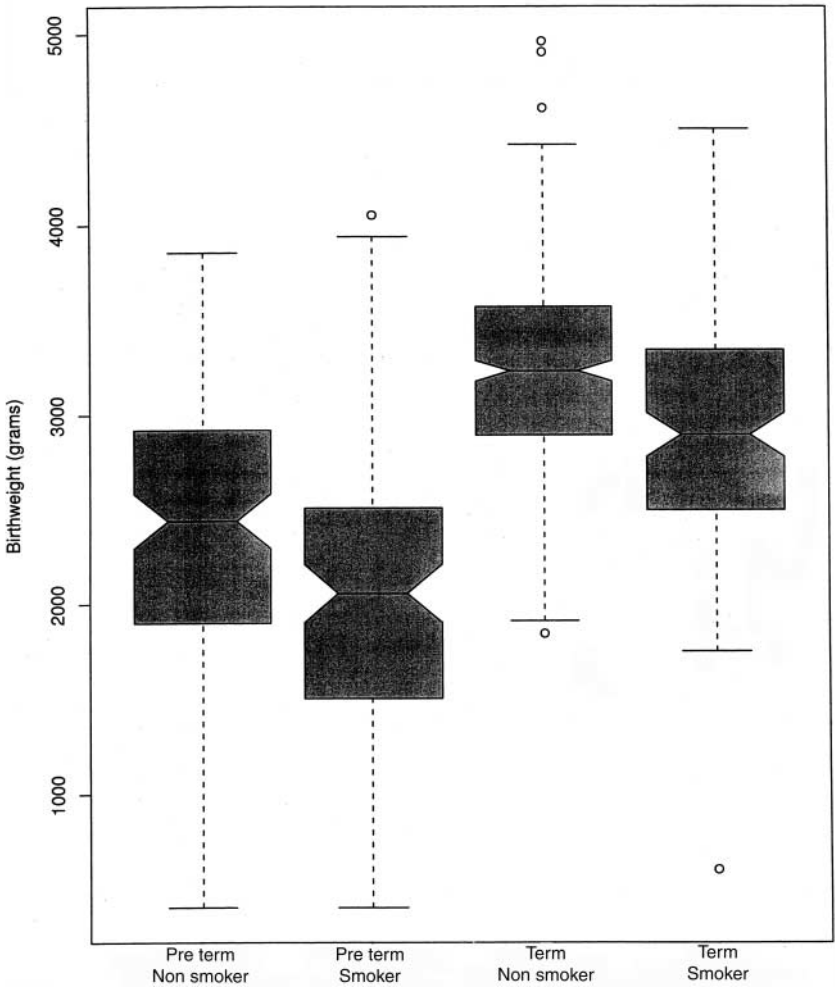

Figure 3. Birthweight distribution, by gestational age and smoking status.

DISCUSSION

In an investigation of the association between maternal cigarette and other substance use and infant birthweight, data collected from women residing in D.C. who delivered livebirths in eight D.C. hospitals were analyzed. Although previous research has investigated the effects of maternal smoking on birthweight, this study offered a unique opportu-

nity to study not only cigarette use by pregnant women, but also their use of alcohol and other illicit drugs. The study also provided an opportunity to examine these relationships in an understudied subpopulation: women giving birth in urban hospitals who were predominantly young, single, and black. Most of the women were also of low income and were receiving some form of public assistance.

Using a multivariable linear regression model that controlled for demographic, maternal, and infant factors, cigarette smoking and heroin use by mothers during pregnancy were associated with notable decreases in the birthweight of their infants. The model estimated that smoking by a mother during pregnancy decreased the birthweight of her infant by about 130 grams, while the birthweights of infants born to heroin users were decreased by 450 grams on average. Conversely, maternal marijuana use seemed to have the reverse effect of increasing birthweight (by 139 grams). Alcohol use and cocaine use by women during pregnancy were not associated with infant birthweight.

These results support previous research findings in indicating that cigarette smoking during pregnancy is a significant contributor to low birthweight. The potential for significant adverse health, behavioral, and emotional effects among low birthweight infants argues for identifying—and acting on—modifiable factors that could reduce the numbers of low birthweight infants born. Cigarette smoking by women during pregnancy is one such factor. Our results indicate that public health efforts aimed at reducing the number of pregnant women who smoke cigarettes during pregnancy could increase the infant birthweight for these women, on average, by about 131 grams. Although stopping pregnant women from using heroin could increase the birthweights of their infants to a even greater extent (450 grams), the prevalence of heroin use is lower than the prevalence of smoking. In our study, only 1.4% of the women reported using heroin during pregnancy compared with 22.5% reporting cigarette use. Thus, focusing public health efforts on smoking cessation could impact a greater number of women and their infants than focusing on illicit drugs.

In this study, 10.5% of women used cocaine during pregnancy but no effect was seen on birthweight in the model. This is consistent with other research that has found no association between cocaine use during pregnancy and infant outcomes (Frank et al., 2001; Shiono et al., 1995), but differs from results of the recent Maternal Lifestyle Study which found higher cocaine exposure in low birthweight infants based on meconium assays (Bauer et al., 2002; Lester et al., 2001) Interestingly, in the latter study, women who used cocaine were much more likely to also smoke cigarettes than were women who did not use cocaine (odds ratio [OR]:

23.1; 95% CI: 19.5–27.4). An unanticipated finding was that women who used marijuana during pregnancy (7.1% in our study) were likely to have infants with higher birthweights (139 grams heavier on average). This finding differs from results of previous studies, which found no relationship between marijuana use during pregnancy and low birthweight (Shiono et al., 1995) or a reduction in infant birthweight associated with marijuana use during pregnancy (Hingson et al., 1982; Zuckerman et al., 1989).

Low birthweight is a significant health risk for all infants, but black infants suffer a disproportionate burden from low birthweight: About 13.0% of babies born to black women are low birthweight compared with only 6.3% of babies born to white women (National Center for Health Statistics, 1998). Our model indicated that the birthweights of black infants were an estimated 207 grams less than the birthweights of white infants. This birthweight deficit for black infants (due to a nexus of genetic and environmental factors that influence the greater overall risk of low birthweight for black infants), along with the added decrease of 131 grams if their mothers smoked during pregnancy, brings the average birthweights for black infants to an even lower level than the birthweights of white infants whose mothers smoked during pregnancy. Encouraging black women to stop smoking during pregnancy could thus confer even greater health benefits for their infants than similar behavior for white women. This could help lessen the health disparity between black and white children because low birthweight is related to infant mortality, chronic disease risk, and developmental or cognitive impairment (Schendel et al., 1997).

CONCLUSIONS

Getting pregnant women to stop smoking during pregnancy could have a significant impact on infant health and associated health care costs, so tailoring smoking cessation programs for this group could have a substantial public health benefit. Our results indicate that smoking during pregnancy is a more significant determinant for low birthweight than the use of alcohol or other substances. Successful smoking cessation programs for pregnant women could increase the birthweights of their infants by 131 grams, on average. Although smoking has decreased in recent years, the prevalence of this behavior is still high among women of childbearing age: 23.1% for white women and 20.8% for black women (Centers for Disease Control and Prevention, 2001). In addition to low birthweight, the use of tobacco products by pregnant women is also asso-

ciated with placenta previa, abruptio placenta, premature rupture of the membranes, intrauterine growth restriction, and sudden infant death syndrome or SIDS (Andres and Day, 2000; Pollack, 2001). A recent study estimated that a decrease of 1% in the prevalence of smoking among pregnant women would prevent 1300 low birthweight births and save about $21 million in direct medical costs in a single year (Lightwood et al., 1999).

Smoking during pregnancy remains a significant health problem, not only for the infants born to smokers, but also for these women's own health (U.S. Department of Health and Human Services, 2001). Given this knowledge, increased resources should be channeled to educate pregnant women (and women of childbearing age) about the multiple problems their smoking can cause their babies and to help them stop smoking. Our results indicate that such programs could be of significant benefit to low-income black women in urban areas. Smoking cessation programs could be offered to these women at prenatal clinics, or as part of Women, Infants, and Children (WIC) services or substance abuse treatment programs, to address the unique characteristics and needs of this study population. Involving at-risk women in the development and implementation of such programs could enhance their success. These women could offer suggestions, based on their own unique experiences and reasons for using cigarettes that would improve the appropriateness of the programs for this subpopulation. They could also act as lay educators to inform other pregnant women about the dangers of smoking during pregnancy and where to go to get help for smoking cessation.

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Abuse and Mental Health Services Administration, or the U.S. Department of Health and Human Services, and no official endorsement by any of these organizations is intended or should be inferred.

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RESUMEN

El impacto que tiene el fumar y usar otras substancias durante el embarazo sobre el recién nacido, se comprueba mediante una muestra de 766 mujeres de una zona urbana. Los datos recopilados provienen del Estudio de Drogas del Área Metropolitana de Washington, DC (DC* MADS, por sus siglas en inglés). En 1992 se entrevistaron a las mujeres residentes de esa zona que dieron a luz en el Distrito de Columbia. Se utilizó un modelo de regresión lineal multivariable para cuantificar la asociación entre el peso al nacer y el uso de cigarrillos, alcohol o drogas ilícitas por parte de las madres durante el embarazo, controlando las variables confusoras. El análisis se enfocó en factores que incluyen el cuidado prenatal y el uso de substancias durante el embarazo, que pueden contribuir al bajo peso de los recién nacidos de las mujeres en su mayoría de raza negra, en esta muestra urbana. El uso de cigarrillos, marihuana y heroína por una mujer durante el embarazo estuvo relacionado con el peso del recién nacido, pero no hubo una relación significativa con el consumo de alcohol y cocaína. El fumar durante el embarazo resultó ser un factor importante para predecir el bajo peso de los recién nacidos, lo que sugiere que el enfocarse en programas para que las mujeres embarazadas dejen de fumar, específicamente aquellas que usan drogas ilegales, podría ayudar a reducir las consecuencias adversas sobre la salud de los recién nacidos de bajo peso.

RÉSUMÉ

L'impact sur le poids du nourrisson de la consommation de tabac et d'autres substances par la mère au cours de la grossesse est mis en évidence à partir d'un échantillon de 766 femmes en milieu urbain, sur la base de données collectées dans le cadre de l'étude sur la consommation de drogues menée dans la région métropolitaine de Washington, DC (Metropolitan Area Drug Study, DC*MADS). En 1992, des femmes résidant et ayant accouché dans le District of Columbia ont été interrogées. Un modéle de régression linéaire à plusieurs variables a été appliqué pour quantifier la corrélation entre le poids à la naissance et la consommation de cigarettes, d'alcool ou de drogues illicites par la mère au cours de la grossesse, tout en contrôlant la présence d'éventuelles variables parasites. L'analyse a porté sur les divers facteurs (dont les soins prénataux et la consommation de substances au cours de la grossesse) susceptibles de contribuer, pour cet échantillon de femmes originaires de milieux urbains et à prédominance noire, à la naissance d'enfants ayant un poids insuffisant. La consommation de cigarettes, de marijuana et d'héroïne par des femmes durant leur grossesse a été mise en relation avec le poids de l'enfant, mais la consommation d'alcool ou de cocaïne au cours de cette période n'a pas fait apparaître de corrélations significatives. Le tabagisme en cours de grossesse s'est avéré constituer une variable prédictive importante du poids trop faible à la naissance, ce qui laisse penser que le fait d'axer davantage de programmes de désaccoutumance au tabac sur les femmes enceintes, et notamment sur celles qui seraient susceptibles d'être également consommatrices de substances illicites, pourrait contribuer à réduire les effets néfastes pour la santé chez les bébés présentant un poids insuffisant à la naissance.

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