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Effects of Residential Indoor Air Quality and Household Ventilation on Preterm Birth and Term Low Birth Weight in Los Angeles County, California

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Abstract

Objectives—The purpose of our study was to examine the effects of indoor residential air quality on preterm birth and term low birth weight (LBW).

Methods—We evaluated 1761 nonsmoking women from a case-control survey of mothers who delivered a baby in 2003 in Los Angeles County, California. In multinomial logistic regression models adjusted for maternal age, education, race/ethnicity, parity and birthplace, we evaluated the effects of living with smokers or using personal or household products that may contain volatile organic compounds and examined the influence of household ventilation.

Results—Compared with unexposed mothers, women exposed to secondhand smoke (SHS) at home had increased odds of term LBW (adjusted odds ratio [OR] = 1.36; 95% confidence interval [CI] = 0.85, 2.18) and preterm birth (adjusted OR = 1.27; 95% CI = 0.95, 1.70), although 95% CIs included the null. No increase in risk was observed for SHS-exposed mothers reporting moderate or high window ventilation. Associations were also observed for product usage, but only for women reporting low or no window ventilation.

Conclusions—Residential window ventilation may mitigate the effects of indoor air pollution among pregnant women in Los Angeles County, California.

Although numerous studies have examined the effects of outdoor air pollution on birth outcomes, less information is available on the effects of residential indoor air quality in high resource countries, even though pregnant women spend on average more than 15 hours per day at or near their home, and 7 hours per day at work or other indoor locations.[1,2] Indoor air quality is influenced not only by the intrusion of outdoor pollutants, but also by the indoor sources such as tobacco smoke, and off-gassing of chemical agents from personal and household products or furniture may also be important contributors.[3] Although studies have reported increased risk of preterm birth and low birth weight (LBW) with maternal

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Human Participant Protection
This research was approved by the Office for Protection of Research Subjects at UCLA, the University of Southern California institutional review board, and by the California State Committee for the Protection of Human Subjects. All participants gave oral or written informed consent prior to completing the survey.

Contributors
J. K. C. Ghosh contributed to the exposure assessment, data analysis, and writing. M. Wilhelm contributed to the study design, analysis, and writing. B. Ritz conceptualized, received funding for, and supervised all aspects of the study and contributed to writing.

smoking and secondhand smoke (SHS) exposures,[4–10] no pregnancy outcome study to date has evaluated the effects of other agents affecting indoor air quality in high resource countries, nor the potential protective effect of home ventilation. The majority of pregnancy outcome studies addressing indoor air pollution beyond SHS were conducted in occupational settings,[11–18] or in low or medium resource countries focusing on smoke from biomass fuels.[19–23]

Volatile organic compounds (VOCs) are present in organic solvents used in many personal products, cleaners, adhesives, and residential-use insecticides.[3,24–26] Most epidemiologic studies of organic solvents examined only occupational exposures, and reported increased risks of spontaneous abortion, small for gestational age (SGA), preterm birth, birth defects, and reductions in birth weight.[11–15,17,18,27,28] Only 2 studies in high resource countries examined residential indoor air exposures from VOC-emitting household products, and neither examined whether ventilation mitigated the effects of exposure.[29,30]

In this study, we describe how SHS, personal and household product usage, as well as household ventilation together influence the risk of preterm birth and term LBW for women in Los Angeles County, California.

METHODS

The Environment and Pregnancy Outcomes Study (EPOS) is a case-control study nested within the 2003 cohort of live births to women who resided in 111 Los Angeles County zip codes located near air pollution monitoring stations or major roadways.[31] We used electronic birth certificates to select live singleton births and identify cases of preterm birth (< 37 weeks completed gestation), LBW (< 2500 g), and controls (full-term normal-weight babies) for a total sample of 6374 babies. Mothers were contacted 3 to 6 months after delivery, and 2543 mothers (40% response rate) completed the survey by phone, mail, or in person. The primary goal of EPOS was to study the effects of outdoor air pollution on birth outcomes, and exposure estimates for criteria air pollutants were calculated based on South Coast Air Quality Management District monitoring station data, and averaged across the dates of the pregnancy (entire pregnancy averages).

Information about maternal age, race/ethnicity, education, birthplace, parity, sex of the infant, prenatal care payment source, and complications of pregnancy and delivery was obtained from birth certificates; race/ethnicity is self-reported on birth certificates and is an important risk factor for these outcomes. The EPOS survey questionnaire provided detailed information on additional risk factors such as smoking, alcohol consumption, and household characteristics.

The survey assessed maternal smoking history (smoked during pregnancy, smoked before but not during pregnancy, never smoked). Because active cigarette smoking is an important confounder,[10] we restricted our analyses to women who reported never actively smoking (727 preterm cases, 159 term LBW cases, 875 controls, total n =1761).

Measures of Indoor Air Quality

We evaluated indoor exposures and indoor air quality, the latter reflecting exposure modification by window ventilation of homes. We assessed SHS exposures by asking mothers how many other people living in the household smoked during her pregnancy (lived with ≥1 smokers [home SHS]) versus not having lived with any smoker (no home SHS). To assess household ventilation, we asked how often windows were kept open at home (never, 1 hour/day, half the day, all day, all night, all the time), and grouped responses as 1 hour per day or never (infrequent or no window ventilation) versus half the day or more (moderate or

high window ventilation). We also created a combined measure of home SHS exposure and window ventilation to assess interactions.

The survey assessed hairspray, insect spray, and nail polish usage (times/day/week/month or never). Usage was categorized as never, occasional (hairspray < 10/month; nail polish or insect spray ≤1/month), regular (hairspray > 10 – < 30/month; nail polish > 1– ≤2/month; insect spray > 1/month), or frequent (hairspray ≥ 30/month; nail polish > 2/month). We also created a summary measure (personal and household product usage), defining a "regular/frequent user" as a woman who used at least 1 of the 3 specified products regularly or more frequently, and those who used these products less frequently or never were considered "infrequent" or "never" users. We also examined indoor air quality as combined product usage and window ventilation, considering window ventilation as a possible effect modifier.

Confounding Variables

Based on previous studies,[31,32] the following variables were considered as key confounders: maternal age, race/ethnicity and birthplace, education, and parity. Other potential confounders included mother's marital status, alcohol use during pregnancy, timing of prenatal care initiation, birth season, and several measures of socioeconomic status (SES), including prenatal care payment source, self-reported family income, home ownership, and a census-based SES metric.[33,34] Because health-related behaviors may act as confounders, we also adjusted for fast food consumption during pregnancy (3–4 days/week, daily, once a week, once a month, never), and prenatal vitamin use (daily, almost daily, sometimes). Gestational age can confound term LBW analyses and was assessed as gestational weeks completed based on birth certificate data. Finally, we used multiple imputation software[35] to impute family income information based on individual and census block group characteristics for the 18.3% of surveyed women missing these data.

Statistical Methods

SAS software version 9.2 (SAS Institute, Cary, NC) was used to conduct all analyses. We used crude and adjusted multinomial logistic regression models to calculate odds ratios (ORs) and 95% confidence intervals (CIs) for individual and combined measures of indoor air quality and our birth outcomes of interest. Full-term normal-weight babies served as controls for both case groups, allowing for direct comparisons of effect measures across outcomes.

Regression models were first adjusted for maternal age, race/ethnicity, education, parity, and birthplace, but we also explored the impact of additional confounders detailed in the previous section. For the term LBW analysis, we explored additional adjustment for gestational age and gestational age squared. To account for differences in outdoor air pollution, we adjusted for entire pregnancy average carbon monoxide, nitrogen dioxide, and particulate matter less than 2.5 micrometers in aerodynamic diameter ($PM_{2.5}$), with each pollutant added to the models separately. To examine the potential for exposure misclassification by time spent at home, we stratified the models by whether the woman reported working outside the home at any time during her pregnancy. This stratification was performed in the preterm birth analysis, but not for term LBW because of the small number of available cases.

The final models were adjusted for maternal age, education, race/ethnicity, parity and maternal birthplace. Further adjustment for other variables described above, including outdoor air pollution, did not change the main effect estimates by more than 5%.

RESULTS

Table 1 shows the distribution of demographic characteristics and health behaviors of the study population. The majority of mothers in our study were Hispanic (73.0%), and more than half were multiparous (61.1%). Nearly all initiated prenatal care in the first trimester (91.2%) and did not use alcohol during pregnancy (94.8%), but 14.3% reported living with 1 or more smokers. Several indicators suggest that the EPOS population is relatively low in SES, with more than 65% having completed high school or with less education, only 35.3% using private insurance for prenatal care, and less than 25% owning the home where they lived during pregnancy.

More than half of the women surveyed reported keeping their windows open at least half of the day (57.1%), consistent with our expectations for households in the mild southern California climate. Some personal and household products were used regularly or frequently, with approximately 15% using hairspray daily or more often and 13.2% using nail polish more than twice a month. However, few women reported using insect spray more than once a month (4.2%).

Table 2 shows adjusted associations for personal and household product usage, home SHS exposure and window ventilation. We did not observe any consistent increased risk with product usage, although CIs were very wide because of the small number of women who reported using each product. Mothers who lived with 1 or more smokers had approximately 30% increased odds of term LBW and preterm birth in adjusted models, but CIs included the null value. Women who reported keeping their windows open for half the day or more had approximately 40% and 20% decreased odds of term LBW and preterm birth, respectively, in adjusted models. None of the women in our study reported regular or frequent use of all 3 personal and household products in our survey. Women who reported regular or frequent use of 1 to 2 of the specified products showed no increased or slightly increased odds of term LBW and preterm birth.

Results for combined measures of residential air quality including pollutant exposures and window ventilation are shown in Table 3, with the reference group representing the lowest exposures and most frequent window ventilation. Among women exposed to SHS at home, those who reported keeping their windows open less than half the day had 3 times the odds of term LBW and 92% increased odds of preterm birth in adjusted models, compared with nonsmoking households with frequent window ventilation. Women living with a smoker and reporting frequent window ventilation had no increased risk of either adverse birth outcome. Nonsmoking households with infrequent window ventilation also had 49% higher odds of term LBW and 25% higher odds of preterm birth, compared with non-smoking households with frequent window ventilation.

When incorporating information about window ventilation to the measure of total personal/household product usage, we found that women who reported regular or frequent usage and low or no window ventilation had 85% and 43% higher odds of term LBW and preterm birth, respectively (Table 3). Women who were regular or frequent users of these products but who kept the windows open at least half the day had no increased risk of either outcome.

We also conducted stratified analyses for preterm birth according to whether a woman worked outside the home at any point during her pregnancy. The only difference we observed was an increased risk of preterm birth for regular users of nail polish or hair-spray among at-home mothers (adjusted OR [95% CI] = 1.72 [1.06, 2.80] for nail polish; 1.71 [0.88, 3.33] for hairspray) but not among working mothers (adjusted OR [95% CI] = 0.80 [0.54, 1.17] for nail polish; 0.73 [0.41, 1.28] for hairspray), compared with nonusers. We

could not stratify analyses for term LBW by work status because of the small number of available cases.

Restricting the data to those who reported never to have smoked accounted for possible confounding by active smoking, however, when we reanalyzed our entire data (n = 2543) adjusting for maternal smoking in our regression models, results were very similar to those we report here for never smokers.

DISCUSSION

Using survey measures of indoor air quality, we found increased risks of term LBW and preterm birth among infants whose mothers reported infrequent or no window ventilation at home, and exposure to either SHS or personal and household products. To our knowledge, this is 1 of only 3 studies to date to report on possible effects of residential indoor air quality on pregnancy outcomes in a high resource country, apart from studies solely examining SHS exposures.[29,30] Different from previous reports, we were also able to evaluate effect measure modification by home window ventilation, and to adjust for outdoor air pollution exposures. Although we would expect residential indoor air pollution to be lower than in most occupational and industrial environments, studies of residential environments are important to elucidate possible health effects in pregnant women from exposures to common products used in unregulated home environments.

The positive associations observed for SHS exposure are supported by previous studies that suggested a detrimental effect on birth weight[6,8,36] although preterm birth studies have been less consistent.[7,9,37] A large California study using cotinine as an SHS marker reported 70% to 80% increases in odds of preterm birth and term LBW for the highest exposure quintile and observed a dose-dependent relationship with mean birth weight and infant length.[5] Our results for the combined metric of SHS exposure and window ventilation suggest that SHS exposure assessment in population-based studies is complex and also that exposures can be mitigated by improved ventilation. Smoking in confined spaces results in high pollutant concentrations, and ventilation has been demonstrated to reduce levels of $PM_{2.5}$ and ultrafine particles.[38,39] Though the biological mechanisms are unknown, potential pathways affected by particulate matter include systemic oxidative stress, pulmonary and placental inflammation, blood coagulation, endothelial function, and hemodynamic responses affecting oxygen and nutrient transport to the fetus.[40] Cosmetic spray products can emit particles small enough to be inhaled into the lungs, where excessive phagocytosis by macrophages can lead to inflammation.[41] The biological mechanisms of VOCs on pregnancy outcomes are largely unknown, but studies have demonstrated that benzene can cross the placenta,[42,43] form DNA adducts which can alter enzyme formation and lead to cell death,[44] and metabolites can cause oxidative stress, which negatively impacts fetal blood cell development.[45–48] Xylenes and ethyl benzene, found in some household products, can cross the human placenta and have been linked to decreased birth weights in animal studies.[24,49]

Associations for personal and household product usage also depended on ventilation status and were weaker than in occupational studies, as expected. There are very few studies that assessed indoor residential VOC exposures among pregnant women. A California study of organic solvent exposure and spontaneous abortion was conducted more than 20 years ago and examined mostly occupational exposures.[30] Residential use of organic solvents was not associated with spontaneous abortion risk, although women who were exposed in both settings were at higher risk than those exposed only at work. Comparing our results to these previous studies may not be justified, because many of the solvents present in occupational settings are not found in residential use products, and some solvents used in the 1980s may

no longer be in use. A recent Danish National Birth Cohort study of paint fumes at home[29] found that mothers exposed during pregnancy were—if anything—at lower risk for SGA; no association was found with preterm birth risk. However, paint fume exposure for 1 to 2 weeks during pregnancy may not be sufficient to produce SGA or preterm birth (i.e., more frequent exposures may be necessary). The authors of this study also acknowledged that they did not collect information about exposure modifying behaviors such as window ventilation when the house was being painted and the paint was drying.

Although every effort was made to recruit the mothers as soon as possible after delivery, as with all retrospective surveys, our results are subject to recall bias. Mothers of preterm or term LBW children may be over-reporting and mothers with normal birth outcomes under-reporting suspected exposures such as SHS, which would bias associations away from the null. Our study is limited by the lack of biomarkers of exposure to confirm survey measures. A California study of nonsmoking women in 1992 found that cotinine concentrations were twice as high in mothers who reported living with 1 or more smokers compared with those in nonsmoking households, making this survey metric a highly relevant predictor of SHS exposure.[50] However, the study also reported that the number of smokers at home only explained 11% of the variation in serum cotinine levels, perhaps because the study was conducted when smoking in the workplace and public places was permitted. California has subsequently banned all smoking in workplaces (as of 1995) and bars and restaurants (as of 1998),[51] so for the women in our study, home SHS exposures account for a much larger percentage of total SHS exposures. It is still possible that cases over-reported SHS exposures to attribute the negative birth outcomes to this cause or that both cases and control mothers under-reported such exposures because women did not want to be seen as harming their baby. However, it is harder to argue that home ventilation and the more complex index we created combining both types of information could have been affected by simple differential reporting bias of case mothers. Similarly, reporting of personal and household product usage may also have been subject to recall bias, but perhaps this would be less likely to be differential with regard to case status than SHS reporting because there are fewer stigmas attached to the use of these products.

Bias from uncontrolled confounding is of concern, particularly for SHS exposure. Women of lower SES in our study were more likely to live with a smoker, and SES is an important predictor of birth outcomes.[52] Thus, although we adjusted for several measures of SES, residual confounding is still a possibility. Although low SES neighborhoods in Los Angeles County have higher outdoor air pollution,[53,54] adjusting for outdoor air pollution did not change our results. Importantly, women who reported keeping their windows open at least half the day tended to be Hispanic or lower in SES, that is, more likely to have lower household incomes, rent their homes, use government-based insurance, and live in a multiunit dwelling. When restricting to Hispanic women, the protective associations for ventilation moved toward the null, although the CI still excluded the null value for term LBW. We also adjusted the models in Table 3 for occupational exposures to indoor air pollution and found that the ORs for SHS-exposed women who had no or low window ventilation increased 5% and 10% for preterm birth and term LBW, respectively, and conversely all other ORs changed less than 2%. Finally, there may have been other sources contributing to indoor air quality not accounted for in our study because we did not collect these data, such as the use of cleaning products, household renovation activities, and off-gassing from new carpeting and furniture.

In using full-term normal-weight babies as the control group for both outcomes, we may have induced an exclusion bias (i.e., a form of selection bias) in our study. Because indoor air quality may affect both preterm birth and term LBW, no single control group provides an unbiased comparison. Thus, when excluding preterm babies from the control group for the

term LBW cases, we induced a selection bias. However, if the control group for term LBW cases were defined as all infants born normal weight, including a small number of preterm normal-weight babies, the effect estimates would likely be biased slightly downward because of the potential positive association between the exposure and preterm birth. Similarly, defining the control group for preterm cases as all full-term infants regardless of weight would have created a slight downward bias because the prevalence of LBW babies among term births is low.

The 40% response rate in our study could have caused bias if women selected themselves for study according to both their pregnancy outcome and specific exposures. As previously reported, despite some demographic differences across response groups, we did not see evidence of response bias in our previous study of outdoor air pollution and preterm birth using the same EPOS dataset in a 2-phase analysis.[31] Although the present study evaluated indoor air quality rather than outdoor air pollution, we would similarly expect minimal bias from nonresponse. Missing data for the personal and household product variables could also have biased our results; participants missing these data had similar distributions of demographic variables as those who reported no or occasional usage.

Our study has several strengths, including the use of a population-based case-control study design nested within a birth cohort, allowing us to evaluate participation bias by comparing participants to nonparticipants. Additionally, using survey measures of indoor air quality allowed us to evaluate exposures over the entire pregnancy, rather than a personal measurement approach, which requires the assumption that short-term (e.g., 1–2 weeks) measures represent conditions over the entire pregnancy. The survey approach also allowed us to evaluate the effects of ventilation, which appears to modify the detrimental effects of SHS and household VOC exposures.

SHS exposure is associated with risk of preterm birth and term LBW, although these adverse associations seem to be mitigated by home ventilation, i.e. opening windows. As there is no risk-free level of SHS,[55] pregnant women should be advised to avoid SHS exposure whenever possible, or mitigate SHS exposure by limiting smoking by household members to outdoor spaces or ventilating their home. Personal and household products containing organic solvents are possibly associated with increased risk of these adverse birth outcomes when used in poorly ventilated areas.

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TABLE 1

Frequencies and Crude ORs of Demographic and Indoor Air Pollution Variables Among Never Smokers: Environment and Pregnancy Outcomes Study, Los Angeles County, CA, 2003

	Preterm (n = 727), Mean ± SD or No. (%)	Term LBW (n = 159), Mean ± SD or No. (%)	Control (n = 875), Mean ± SD or No. (%)	Preterm Crude OR (95% CI)	Term LBW Crude OR (95% CI)
Birth weight, g	2839.7 ± 763.3	2283.4 ± 199.0	3421.1 ± 437.9	…	…
Gestational age, d	241.7 ± 19.8	273.8 ± 11.6	278.3 ± 10.4	…	…
Demographic variables					
Maternal age, y					
< 20	93 (12.8)	21 (13.2)	95 (10.9)	1.21 (0.77, 1.65)	1.10 (0.55, 1.87)
20–24	155 (21.3)	39 (24.5)	185 (21.1)	1.00 (Ref)	1.00 (Ref)
25–29	181 (24.9)	38 (23.9)	272 (31.1)	0.77 (0.55, 1.10)	0.66 (0.44, 1.10)
30–34	189 (26.0)	42 (26.4)	215 (24.6)	1.10 (0.77, 1.43)	0.88 (0.55, 1.54)
≥ 35	109 (15.0)	19 (11.9)	108 (12.3)	1.21 (0.88, 1.65)	0.88 (0.44, 1.54)
Maternal race/ethnicity					
Non-Hispanic White	79 (10.9)	8 (5.0)	113 (12.9)	1.00 (Ref)	1.00 (Ref)
Hispanic White	535 (73.6)	122 (76.7)	628 (71.8)	1.21 (0.88, 1.65)	2.75 (1.32, 5.72)
Black	51 (7.0)	13 (8.2)	48 (5.5)	1.54 (0.88, 2.53)	3.85 (1.54, 9.79)
Asian[a]	26 (3.6)	9 (5.7)	49 (5.6)	0.77 (0.44, 1.32)	2.64 (0.99, 7.15)
Other[b]	32 (4.4)	7 (4.4)	31 (3.5)	1.43 (0.88, 2.64)	3.19 (1.10, 9.46)
Missing	4 (0.6)	0 (0.0)	6 (0.7)	…	…
Maternal education, y					
≤8	127 (17.5)	28 (17.6)	135 (15.4)	1.10 (0.77, 1.43)	1.43 (0.77, 2.42)
9–11	171 (23.5)	39 (24.5)	202 (23.1)	0.99 (0.77, 1.21)	1.32 (0.77, 2.20)
12	199 (27.4)	33 (20.8)	223 (25.5)	1.00 (Ref)	1.00 (Ref)
13–15	109 (15.0)	30 (18.9)	123 (14.1)	0.99 (0.77, 1.32)	1.65 (0.99, 2.86)
≥ 16	111 (15.3)	27 (17.0)	171 (19.5)	0.77 (0.55, 0.99)	1.10 (0.66, 1.87)
Missing	10 (1.4)	2 (1.3)	21 (2.4)	…	…
Maternal marital status					
Single, separated, divorced, and widowed	129 (17.7)	39 (24.5)	171 (19.5)	1.32 (0.99, 1.65)	1.21 (0.77, 1.76)
Living together but not married	201 (27.6)	38 (23.9)	198 (22.6)	0.99 (0.77, 1.21)	1.43 (0.88, 2.20)

	Preterm (n = 727), Mean ± SD or No. (%)	Term LBW (n = 159), Mean ± SD or No. (%)	Control (n = 875), Mean ± SD or No. (%)	Preterm Crude OR (95% CI)	Term LBW Crude OR (95% CI)
Married	392 (53.9)	81 (50.9)	501 (57.3)	1.00 (Ref)	1.00 (Ref)
Missing	5 (0.7)	1 (0.6)	5 (0.6)	…	…
Payment source for prenatal care					
Private insurance[c]	250 (34.4)	48 (30.2)	322 (36.8)	1.00 (Ref)	1.00 (Ref)
Public insurance[d]	465 (64.0)	110 (69.2)	541 (61.8)	1.10 (0.88, 1.32)	1.32 (0.99, 1.98)
No insurance/other[e]	12 (1.7)	1 (0.6)	9 (1.0)	1.76 (0.66, 4.18)	0.77 (0.11, 6.05)
Missing	0 (0.0)	0 (0.0)	3 (0.3)	…	…
Parity					
≥ 1	455 (62.6)	86 (54.1)	535 (61.1)	1.00 (Ref)	1.00 (Ref)
0	272 (37.4)	73 (45.9)	340 (38.9)	0.99 (0.77, 1.10)	1.32 (0.99, 1.87)
Maternal birthplace					
Foreign-born	487 (67.0)	101 (63.5)	585 (66.9)	0.99 (0.77, 1.21)	0.88 (0.66, 1.21)
US-born	239 (32.9)	57 (35.8)	290 (33.1)	1.00 (Ref)	1.00 (Ref)
Missing	1 (0.1)	1 (0.6)	0 (0.0)	…	…
Maternal birthplace					
Mexico	312 (42.9)	62 (39.0)	395 (45.1)	0.99 (0.77, 1.21)	0.77 (0.55, 1.21)
Other (outside US)	175 (24.1)	39 (24.5)	190 (21.7)	1.10 (0.88, 1.43)	0.99 (0.66, 1.65)
United States	239 (32.9)	57 (35.8)	290 (33.1)	1.00 (Ref)	1.00 (Ref)
Missing	1 (0.1)	1 (0.6)	0 (0.0)	…	…
Mother worked outside the home at any point during pregnancy					
No	381 (52.4)	68 (42.8)	439 (50.2)	1.00 (Ref)	1.00 (Ref)
Yes	344 (47.3)	89 (56.0)	430 (49.1)	0.88 (0.77, 1.10)	1.32 (0.99, 1.87)
Missing	2 (0.3)	2 (1.3)	6 (0.7)	…	…
Owned the home in which she lived at any point during pregnancy					
Own	165 (22.7)	40 (25.2)	210 (24.0)	1.00 (Ref)	1.00 (Ref)
Rent	556 (76.5)	115 (72.3)	655 (74.9)	1.10 (0.88, 1.32)	0.88 (0.66, 1.32)
Missing	6 (0.8)	4 (2.5)	10 (1.1)	…	…
Annual household income, $					
< 40 000	451 (62.0)	95 (59.7)	537 (61.4)	1.10 (0.88, 1.43)	1.10 (0.66, 1.65)

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	Preterm (n = 727), Mean ± SD or No. (%)	Term LBW (n = 159), Mean ± SD or No. (%)	Control (n = 875), Mean ± SD or No. (%)	Preterm Crude OR (95% CI)	Term LBW Crude OR (95% CI)
≥ 40 000	140 (19.3)	30 (18.9)	185 (21.1)	1.00 (Ref)	1.00 (Ref)
Missing	136 (18.7)	34 (21.4)	153 (17.5)	…	…
Health behaviors					
Prenatal care					
Began in trimester 1	654 (90.0)	136 (85.5)	816 (93.3)	1.00 (Ref)	1.00 (Ref)
Began in trimester 2 or 3 or no prenatal care	70 (9.6)	21 (13.2)	53 (6.1)	1.65 (1.10, 2.42)	2.42 (1.43, 4.07)
Missing	3 (0.4)	2 (1.3)	6 (0.7)	…	…
Lived with ≥ 1 smokers during pregnancy					
Did not live with smoker	607 (83.5)	132 (83.0)	755 (86.3)	1.00 (Ref)	1.00 (Ref)
Lived with smoker	115 (15.8)	27 (17.0)	110 (12.6)	1.32 (0.99, 1.76)	1.43 (0.88, 2.20)
Missing	5 (0.7)	0 (0.0)	10 (1.1)	…	…
Used alcohol during pregnancy					
No	693 (95.3)	148 (93.1)	828 (94.6)	1.00 (Ref)	1.00 (Ref)
Yes	32 (4.4)	11 (6.9)	46 (5.3)	0.88 (0.55, 1.32)	1.32 (0.66, 2.64)
Missing	2 (0.3)	0 (0.0)	1 (0.1)	…	…

Note. CI = confidence interval; LBW = low birth weight; OR = odds ratio. The sample size was n = 1761.

[a]Includes Chinese, Japanese, Korean, Vietnamese, Cambodian, Thai, Laotian, Filipino, Indian, and other Asian.

[b]Includes Native American, Eskimo, Aleut, Hawaiian, Guamanian, Samoan, Pacific Islanders, and others.

[c]Includes private insurance, HMO, and Blue Cross and Blue Shield.

[d]Includes Medicare, Medi-Cal, government, and other nongovernment programs.

[e]Includes no prenatal care, self-pay, no charge, medically indigent, and other.

TABLE 2

Analyses of Term Low Birth Weight and Preterm Birth Using Individual Household Indoor Air Pollution Variables Among Never Smokers: Environment and Pregnancy Outcomes Study, Los Angeles County, CA, 2003

	Term LBW Cases (n = 159), No.	Preterm Cases (n = 727), No.	Controls (n = 875), No.	Term LBW, Adjusted OR[a] (95% CI)	Preterm, Adjusted OR[b] (95% CI)
Personal and household products					
Nail polish use					
Never	89	394	472	1.00 (Ref)	1.00 (Ref)
Occasional	22	116	159	0.76 (0.45, 1.26)	0.89 (0.67, 1.18)
Regular	10	66	68	0.78 (0.38, 1.60)	1.22 (0.83, 1.78)
Frequent	31	88	113	1.42 (0.88, 2.27)	0.90 (0.66, 1.24)
Missing	7	63	63	…	…
Hairspray use					
Never	104	420	525	1.00 (Ref)	1.00 (Ref)
Occasional	18	97	104	0.86 (0.49, 1.49)	1.18 (0.87, 1.62)
Regular	8	32	33	1.14 (0.50, 2.61)	1.26 (0.75, 2.11)
Frequent	19	104	139	0.70 (0.41, 1.20)	0.94 (0.70, 1.26)
Missing	10	74	74	…	…
Insect spray use					
Never	132	578	699	1.00 (Ref)	1.00 (Ref)
Occasional	9	30	45	1.19 (0.56, 2.53)	0.86 (0.53, 1.40)
Regular/frequent	5	30	39	0.62 (0.23, 1.62)	0.86 (0.52, 1.41)
Missing	13	89	92	…	…
Personal and household product usage[c]					
Infrequent users and nonusers	90	392	494	1.00 (Ref)	1.00 (Ref)
Regular/frequent users	57	254	295	1.05 (0.72, 1.53)	1.08 (0.86, 1.35)
Missing	12	81	86	…	…
Other indoor air quality contributors and mitigators					
Home SHS exposure[d]					
No	132	607	755	1.00 (Ref)	1.00 (Ref)
Yes	27	115	110	1.34 (0.84, 2.16)	1.27 (0.95, 1.70)

	Term LBW Cases (n = 159), No.	Preterm Cases (n = 727), No.	Controls (n = 875), No.	Term LBW, Adjusted OR[a] (95% CI)	Preterm, Adjusted OR[b] (95% CI)
Missing	0	5	10	…	…
Home window ventilation[e]					
Infrequent/no window ventilation	81	315	347	1.00 (Ref)	1.00 (Ref)
Moderate/high window ventilation	78	408	520	0.60 (0.42, 0.86)	0.79 (0.64, 0.98)
Missing	0	4	8	…	…

Note. CI = confidence interval; LBW = low birth weight; OR = odds ratio; SHS = secondhand smoke. The sample size was n = 1761.

[a]Adjusted for maternal age, race/ethnicity, education, parity, and mother's birthplace (US, Mexico, other outside US).

[b]Adjusted for maternal age, race/ethnicity, education, parity, and mother's birthplace (US, Mexico, other outside US).

[c]Regular and frequent personal and household product use classified as having used at least 1 of 3 specified products (nail polish, hairspray, insect spray) regularly or frequently during pregnancy.

[d]Home SHS exposure defined as living with ≥ 1 smokers during pregnancy.

[e]Home window ventilation measure is based on how often the mother reported keeping windows open during pregnancy. Low or no window ventilation represents 1 hour per day or never. Moderate or high window ventilation represents half the day, all day, all night, or all the time.

TABLE 3

Analyses of Term Low Birth Weight and Preterm Birth Using Summary Measures of Indoor Air Pollution Variables Among Never Smokers: Environment Pregnancy and Outcomes Study, Los Angeles County, CA, 2003

	Term LBW cases (n = 159)	Preterm cases (n = 727)	Controls (n = 875)	Term LBW Adjusted[a] OR (95% CI)	Preterm Adjusted[b] OR (95% CI)
Home SHS and home window ventilation[c]					
No home SHS, moderate/high window ventilation	67	337	443	1.00 (Ref)	1.00 (Ref)
No home SHS, infrequent/no window ventilation	65	266	304	1.49 (1.01, 2.20)	1.25 (0.99, 1.56)
Home SHS, moderate/high window ventilation	11	68	73	0.90 (0.45, 1.81)	1.15 (0.80, 1.66)
Home SHS, infrequent/no window ventilation	16	47	37	3.20 (1.63, 6.28)	1.92 (1.19, 3.09)
Missing	0	9	18	…	…
Personal and household product usage and home window ventilation[d]					
Low users and nonusers, moderate/high window ventilation	47	229	306	1.00 (Ref)	1.00 (Ref)
Low users and nonusers, infrequent/no window ventilation	43	160	184	1.68 (1.05, 2.68)	1.26 (0.95, 1.68)
Regular/frequent users, moderate/high window ventilation	24	132	170	0.92 (0.54, 1.57)	1.02 (0.76, 1.36)
Regular/frequent users, infrequent/no window ventilation	33	122	125	1.85 (1.10, 3.12)	1.43 (1.04, 1.97)
Missing	12	84	90	…	…

Note. CI = confidence interval; LBW = low birth weight; OR = odds ratio; SHS = secondhand smoke. The sample size was n = 1761.

[a]Adjusted for maternal age, race/ethnicity, education, parity, and mother's birthplace (US, Mexico, other outside US).

[b]Adjusted for maternal age, race/ethnicity, education, parity, and mother's birthplace (US, Mexico, other outside US).

[c]SHS exposure defined as living with one or more smokers. Frequent window ventilation defined as keeping the windows open in home at least half the day.

[d]Regular/frequent personal and household product use classified as having used at least 1 of 3 specified products (nail polish, hairspray, insect spray) regularly or frequently during pregnancy. Window ventilation defined as keeping the windows open on average at least half the day.