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Social determinants of smoke exposure during pregnancy: Findings from waves 1 & 2 of the Population Assessment of Tobacco and Health (PATH) Study

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ABSTRACT

Maternal smoking during pregnancy (MSDP) and secondhand smoke (SHS) exposure are associated with a myriad of negative health effects for both mother and child. However, less is known regarding social determinants for SHS exposure, which may differ from those of maternal smoking during pregnancy (MSDP). To identify social determinants for SHS exposure only, MSDP only, and MSDP and SHS exposure, data were obtained from all pregnant women (18–54 years; N = 726) in waves 1 and 2 of the Population Assessment of Tobacco and Health Study (2014–2015). Multiple logistic regressions were conducted using SAS 9.4. Smoke exposure during pregnancy was common; 23.0% reported SHS exposure only, 6.1% reported MSDP only, and 11.8% reported both SHS exposure and MSDP. Results demonstrate that relationships between smoke exposure during pregnancy and social determinants vary by type of exposure. Women at risk for any smoke exposure during pregnancy include those who are unmarried and allow the use of combustible tobacco products within the home. Those who are at higher risk for SHS exposure include those who are younger in age, and those who are earlier in their pregnancy. Those who are at higher risk for maternal smoking include those with fair/poor mental health status and those who believe that others' view tobacco use more positively. These results suggest the need for implementing more comprehensive policies that promote smoke-free environments. Implementing these strategies have the potential to improve maternal and fetal health outcomes associated with tobacco smoke exposure.

1. Introduction

Addressing maternal smoking and secondhand smoke (SHS) exposure during pregnancy is a pressing public health concern. Maternal smoking, or the use of any tobacco product, during pregnancy (MSDP) is associated with an increased risk of placental abruption and adverse birth outcomes, such as preterm delivery, low birth weight, and sudden infant death syndrome (United States Department of Health and Human Services, 2001). Much like MSDP, there are also negative health outcomes associated with SHS exposure during pregnancy, resulting from the inhalation of smoke from externally sourced burning tobacco products (U.S. Department of Health and Human Services, 2014). SHS exposure is associated with increased risk for reduced birth weight, decreased lung function (Goel et al., 2004), and other negative effects in the child, such as stillbirth and congenital malformations (Leonardi-Bee et al., 2011).

Smoke-related birth complications result in an estimated \$2 billion in direct health care costs in the US annually (Anon., 1995). Maternal smoking has been estimated to add \$724 to the average neonatal cost of birth (Adams et al., 2002), contributing to about 9% of the total direct medical costs in the first year of life (Leung et al., 2003). It also results in greater utilization of health care services in early childhood (Batscheider et al., 2012). Despite the dangers and costs associated with maternal smoking, rates remain high (approximately 10%, according to reports from the 2011 Pregnancy Risk Assessment and Monitoring System (Centers for Disease Control and Prevention, 2017)), particularly among disadvantaged populations (Drake et al., 2016). SHS exposure is estimated to contribute to more than \$5 billion in direct medical costs and \$4.7 billion in lost productivity costs annually, with certain segments of the population particularly vulnerable to smoke exposure (Institute of Medicine, 2007).

The existing literature has focused heavily on risk factors for, and

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negative outcomes associated with, maternal smoking. A recently published study using data from wave 1 of the Population Assessment for Tobacco and Health (PATH) study finds that poverty, low educational attainment, and White race/ethnicity were associated with maternal smoking (Kurti et al., 2017). Other studies find that pregnant women are more likely to smoke during the perinatal period if they: have lower socioeconomic (SES) status (Egebjerg Jensen et al., 2008) (e.g. lower education, lower incomes (Bailey, 2006), have unskilled manual occupations or are unemployed), live in rented accommodations, are single (Penn and Owen, 2002; Schneider and Schütz, 2008), have a partner who smokes and/or are exposed to passive smoking during pregnancy (Al-Sahab et al., 2010; Paterson et al., 2003), and have a long history of smoking (Bailey, 2006).

Despite the growing literature on the prevalence, risk factors for, and health consequences of maternal smoking, less is known regarding risk factors associated with SHS exposure among pregnant women. Much of the existing literature focused on determinants of SHS exposure among reproductive aged women (who may be non-pregnant or pregnant) have been conducted in countries outside of the US. A study in India suggests that women of reproductive age are exposed to smoke more often at home than within the workplace (Agrawal et al., 2015). Another study conducted in Mexico among pregnant women finds that SHS exposure within the home is not limited to a husband/partner who smokes, but also includes others living within the household (e.g. parents, parents-in-law, siblings, aunts and uncles) (Campollo et al., 2015). Additionally, pregnant women with lower levels of education and who are younger in age may be at increased risk for being exposed to SHS at home and within public places, according to a study conducted in Greece (Vardavas et al., 2010).

Given the heterogeneity in smoking prevalence across countries and regions (Bloch et al., 2008), findings from these international studies might not reflect the same patterns found in the US and should be evaluated, accordingly. For example, within the US, women of child-bearing age are present in the workplace in greater numbers, and most pregnant women work throughout most of their pregnancy (Gao and Livingston, 2015). This is an important point since subgroups of working women may be at higher risk for negative health effects of SHS during pregnancy, due to working in environments with higher SHS exposure (Misra and Nguyen, 1999). In 2014, < 50% of individuals in the US were covered by smoke-free legislation protecting workers from smoke exposure in all indoor, private, non-hospitality workplaces (e.g. offices, factories, and warehouses), restaurants, and bars. Data from the 2010 National Health Interview Survey reports that 9% of non-smoking women of reproductive age experience SHS exposure at work, with prevalence estimates decreasing with increasing age, education, and earnings – suggesting that the same women who are at highest risk for adverse pregnancy outcomes within the general population are also at increased risk of being exposed to smoke within the workplace (Johnson et al., 2015).

Public health burdens associated with smoke exposure during pregnancy are high. While greater attention has been given to maternal smoking, there exists a limited number of nationally-representative studies focused on correlates of SHS exposure during pregnancy. This study seeks to address this gap in the literature by examining social determinants of maternal smoking and of SHS exposure among self-reported non-smokers in the Population Assessment of Tobacco and Health (PATH) Study. The aim of this study is to: identify social determinants associated with maternal smoking only, SHS exposure during pregnancy only, and maternal smoking paired with SHS exposure during pregnancy, including sociodemographic factors, smoke-free home policies, peer/family approval of tobacco use, and self-reported health perceptions.

2. Methods

2.1. Data source

The PATH Study is a household-based, nationally representative, longitudinal cohort study of adults and youth in the US, made publicly available by the National Addiction & HIV Data Archive Program. Methods and conceptual framework for the PATH study is further described elsewhere (Hyland et al., 2017). Briefly, participants were recruited via an address-based, area-probability sampling approach. Adult tobacco users, young adults (18–24 years), and African-Americans were oversampled relative to population proportions. Weighted data adjusts for non-response bias and oversampling and yield representative estimates of the non-institutionalized, civilian US population. Audio-Computer Assisted Self-Interviews (CASI) available in English and Spanish were used to collect information on tobacco-use patterns and associated health behaviors.

2.2. Analytic sample

The analytic sample for this study was limited to data provided by all pregnant women aged 18–54 years in wave 1 (n = 373) and wave 2 (n = 353) of the PATH Study (N = 726, 2014–2015). No women indicated that they were pregnant in both waves of the data. The Institutional Review Board for Westat approved the study design and protocol, the Office of Management and Budget approved the data collection, and the current study was approved as exempt by the Institutional Review Board at Virginia Commonwealth University.

2.3. Outcome measures

Outcome measures were created using a total of 12 items. Eight of these measures were used to determine maternal smoking, by asking participants whether they had used any of the following tobacco products within the past 30 days: cigarettes, e-cigarettes, cigars, cigarillos, hookah, smokeless tobacco, snus, and/or dissolvable tobacco. Each of these items were coded as: yes (1) or no (0). Where participants indicated that they had not used any tobacco product listed within the past 30 days, maternal smoking was coded as no (0); where participants indicated that they had used any of the tobacco products listed in the past 30 days, maternal smoking was coded as yes (1). SHS exposure at home or work was derived from three items measuring smoke exposure from combustible tobacco products within the household [e.g. “Does anyone who lives with you now smoke cigarettes?”, “Does anyone who lives with you now use cigars, cigarillos, or filtered cigars?”, and “Does anyone who lives with you now not use any tobacco products?”, coded as yes (1) or no (0)] and one item measuring tobacco exposure at work [e.g. “How recently has someone smoked around you at work?”, with responses indicating “today”, “in the past week”, “in the past two weeks” and “in the past month” recoded as yes (1) and “longer than a month to more than a year” and “never” as no (0)]. These re-coded measures were used to create a four-category variable indicating the level of smoke exposure: no smoke exposure (n = 328), MSDP only (n = 165), SHS exposure during pregnancy only (n = 75), and both MSDP and SHS exposure during pregnancy (n = 152). This four-category variable was used to separate create binary measures for regression analyses, so that the no smoke exposure group could be compared to the MSDP only group, SHS exposure during pregnancy only group, and the MSDP and SHS exposure during pregnancy group, separately.

2.4. Sociodemographic factors

Sociodemographic factors were measured as categorical variables and included self-reported race/ethnicity (e.g. Black; White; and Other), age (e.g. 18–24 years; 25–54 years), education (e.g. less than high school; GED/high school graduate; some college or associates; and

Table 1
Tobacco exposure among pregnant women by sociodemographic variables.

	Not Exposed		SHS Exposed only		Chi-square, p	Maternal Smoking only		Chi-square, p	Maternal Smoking & SHS Exposed		Chi-square, p
	N	Weighted N (%)	N	Weighted N (%)		N	Weighted N (%)		N	Weighted N (%)	
Gestational age											
1st trimester	78	559,748 (24.4)	46	265,831 (29.8)	1.3, 0.52	23	62,660 (26.6)	0.5, 0.770	60	179,982 (39.3)	8.1, 0.02*
2nd trimester	128	974,147 (42.5)	59	320,086 (35.9)		28	87,206 (37.0)		48	152,226 (33.3)	
3rd trimester	122	757,951 (33.1)	60	306,068 (34.3)		24	85,765 (36.4)		44	125,431 (27.4)	
Age at interview											
18 to 24 years	147	608,075 (26.5)	103	393,911 (44.2)	10.6,	30	69,045 (29.3)	0.2, 0.64*	88	209,944 (45.9)	16.2,
25 to 54 years	181	1,683,771 (73.5)	62	498,074 (55.8)	< 0.01*	45	166,585 (70.7)		64	247,696 (54.1)	< 0.01*
Marital status											
Married	102	926,320 (74.5)	30	270,663 (58.7)	3.9, 0.05*	8	27,977 (21.9)	26.4,	20	72,505 (33.4)	28.1,
Unmarried	68	316,541 (25.5)	48	190,582 (41.3)		29	99,720 (78.1)	< 0.01*	47	144,358 (66.6)	< 0.01*
Race/ethnicity											
White	227	1,678,822 (75.6)	109	646,687 (75.2)	0.0, 1.00	48	145,654 (63.2)	2.9, 0.242.9	116	368,859 (81.1)	2.6, 0.28
Black	56	257,103 (11.6)	26	101,270 (11.8)		14	48,670 (21.1)		19	53,151 (11.7)	
Other race/ethnicity	30	284,705 (12.8)	25	112,432 (13.1)		11	36,025 (15.6)		15	32,651 (7.2)	
Education level											
< High school	37	218,850 (9.6)	24	107,509 (12.1)	8.8, 0.03*	23	57,887 (24.6)	28.0,	31	87,686 (19.2)	32.2,
High school diploma/GED	69	486,796 (21.4)	56	292,185 (32.8)		27	88,068 (37.4)	< 0.01*	66	190,069 (41.5)	< 0.01*
Some college education	119	656,150 (28.8)	64	290,576 (32.6)		23	81,384 (34.5)		45	134,584 (29.4)	
At least bachelor's degree	102	916,856 (40.2)	21	201,715 (22.6)		2	8291 (3.5)		10	45,300 (9.9)	

Note: Not exposed indicates pregnant women who were not exposed to tobacco smoke at work and/or at home and did not report any tobacco use within the past 30 days. SHS Exposed indicates pregnant women who did not report any tobacco use within the past 30 days and were exposed to tobacco smoke at work and/or at home. Maternal smoking indicates pregnant women who reported tobacco use within the past 30 days and were not exposed to second hand smoke at work and/or at home. Weighted % shows the column percent. Chi-Square, p-values are shown for Rao-Scott Modified Chi-Square or Wald Chi-Square Tests (e.g. SHS exposed vs. Not Exposed in the sixth column, and Maternal Smoking vs. Not Exposed in the last column). Unmarried includes: widowed, divorced, separated, and never married categories. At least bachelor's degree includes: Bachelor's and Advanced Degree categories.

* indicates statistical significance at a p-value ≤ 0.05 .

bachelors/advanced degree), and marital status (e.g. now married, widowed/divorced/separated/never married).

2.5. Smoke-free home policies and peer/family approval of smoking

Other factors included smoke-free home policies, peer/family approval of tobacco, and self-reported health perceptions. Smoke-free home policies were measured using two items. Each question asked whether [combustible/non-combustible] tobacco in the home is: not allowed anywhere or anytime, allowed some places some of the time, or allowed anywhere anytime. These measures were dichotomized into “allows use” inclusive of allowed some places some of the time and allowed anywhere anytime (1) or “disallows use” inclusive of not allowed anywhere or anytime (0) within the home. Peer/family approval of tobacco was measured using two separate items. One item asked, “Thinking about the people who are important to you, how would you describe their views on tobacco?” Responses were coded as positive, neutral, and negative. The other item asked, “In general, do you think most people disapprove of smoking cigarettes?” This item was coded as “yes” for responses of “definitely yes” and probably “yes” (1) and “no” for responses of “definitely no” and “probably no” (0). Self-reported health perceptions were measured using two items, asking how the participant rates her physical and mental health. These items were coded as fair/poor (1) and excellent/very good/good (0).

2.6. Statistical analysis

Rao-Scott Chi-Square and Wald Chi-Square tests were used to determine whether there were differences in social determinants by tobacco exposure group. Logistic regression was used to examine risk

factors for tobacco smoke exposure, separately for each smoke exposure group compared to the group that was not smoke exposed. First, unadjusted logistic regression models were used to examine each of the variables of interest with the outcome independently. Second, step-wise adjusted logistic regression models were conducted to determine which variables remained significantly associated with the outcome, after controlling for the others. Odds ratios were estimated for multiple logistic regression analyses. Survey procedures were used to account for weighting and calculating proportions with 95% confidence intervals for all measures; these analyses were all conducted using PROC SURVEYLOGISTIC in SAS 9.4 (SAS Institute Inc.; Cary, NC).

3. Results

3.1. Descriptive analyses

Of the pregnant women included within this study, 27.6%, 39.3%, and 33.2% were in their first, second, and third trimesters of pregnancy respectively. Additionally, 59.1% reported no smoke exposure, 23.0% reported SHS exposure only, and 6.1% reported MSDP only, and 11.8% report both MSDP and SHS exposure. A majority of women reported being White (75.7%), followed by “other” race/ethnicity (12.2%), and Black (12.1%). At time of interview, 32.8% of women reported being between 18 and 24 years and 67.2% were between 25 and 54 years. 12.1% reported having less than a high school education, 27.2% reported obtaining a high school diploma/GED, 30.2% reported having some college education, and 30.5% reported obtaining either a bachelors or advanced degree. A majority (63.3%) reported being currently married.

Table 2
Tobacco exposure among pregnant women by smoke-free home policies, peer/family approval of tobacco use and self-reported health perceptions.

	Not Exposed			SHS Exposed only			Maternal Smoking only			Maternal Smoking & SHS Exposed		
	Weighted N (%)		N	Weighted N (%)		N	Weighted N (%)		N	Weight N (%)		Chi-square, p
	N	Weighted N (%)		N	Weighted N (%)		N	Weight N (%)				
Smoke-free home policies	309	2,205,568 (96.4)	131	710,642 (79.7)	49	158,051 (67.1)	68	224,522 (49.1)	56.5, < 0.01*	25	83,005 (18.1)	148.5, < 0.01*
Combustible tobacco: does not allow	18	82,918 (3.6)	34	181,342 (20.3)	26	77,580 (32.9)	84	233,118 (50.9)		82	232,608 (50.8)	
Combustible tobacco: allows	265	1,899,391 (83.2)	120	667,592 (75.2)	45	150,904 (64.0)	61	187,426 (41.2)	9.8, < 0.01*	45	142,027 (31.0)	60.1, < 0.01*
Non-combustible tobacco: does not allow	61	382,179 (16.8)	44	220,633 (24.8)	30	84,727 (36.0)	90	267,384 (58.8)		14	45,871 (21.2)	0.1, 0.71
Non-combustible tobacco: allows	9	51,076 (4.1)	15	59,508 (12.2)	6	17,273 (8.1)	25	83,005 (18.1)	7.8, 0.02*	53	170,991 (78.8)	44.8, < 0.01*
Peer/family approval of smoking	53	251,355 (20.2)	46	220,739 (45.3)	27	77,570 (36.4)	82	232,608 (50.8)		25	83,005 (18.1)	
Thinking about the people who are important to you, how would you describe their views on using tobacco?	154	943,417 (75.7)	55	206,503 (42.4)	39	118,198 (55.5)	45	142,027 (31.0)		45	142,027 (31.0)	
Positive	46	233,138 (18.8)	31	193,575 (42.0)	6	35,480 (27.8)	14	45,871 (21.2)	0.65, 0.42	14	45,871 (21.2)	0.1, 0.71
Neutral	124	1,008,557 (81.2)	47	267,670 (58.0)	31	92,217 (72.2)	53	170,991 (78.8)		53	170,991 (78.8)	
Very negative	308	2,171,716 (94.8)	151	815,897 (91.5)	57	184,274 (78.2)	129	398,100 (87.0)	16.6, < 0.01*	129	398,100 (87.0)	6.9, < 0.01*
In general do you think most people disapprove of smoking cigarettes?	20	120,130 (5.2)	14	76,087 (8.5)	18	51,357 (21.8)	23	59,540 (13.0)		23	59,540 (13.0)	
Definitely/probably yes	297	2,131,681 (93.0)	141	781,343 (87.6)	51	160,254 (68.0)	115	367,016 (80.2)	30.7, < 0.01*	115	367,016 (80.2)	17.0, < 0.01*
Definitely/probably no	31	160,165 (7.0)	24	110,642 (12.4)	24	75,376 (32.0)	37	90,624 (19.8)		37	90,624 (19.8)	
Self-reported health perceptions												
In general, how would you rate your physical health?												
Excellent/very good/good	308	2,171,716 (94.8)	151	815,897 (91.5)	57	184,274 (78.2)	129	398,100 (87.0)	16.6, < 0.01*	129	398,100 (87.0)	6.9, < 0.01*
Fair/poor	20	120,130 (5.2)	14	76,087 (8.5)	18	51,357 (21.8)	23	59,540 (13.0)		23	59,540 (13.0)	
In general, how would you rate your mental health?												
Excellent/very good/good	297	2,131,681 (93.0)	141	781,343 (87.6)	51	160,254 (68.0)	115	367,016 (80.2)	30.7, < 0.01*	115	367,016 (80.2)	17.0, < 0.01*
Fair/poor	31	160,165 (7.0)	24	110,642 (12.4)	24	75,376 (32.0)	37	90,624 (19.8)		37	90,624 (19.8)	

Note: Not exposed indicates pregnant women who were not exposed to tobacco smoke at work and/or at home and did not report any tobacco use within the past 30 days. SHS Exposed indicates pregnant women who did not report any tobacco use within the past 30 days and were exposed to tobacco smoke at work and/or at home. Maternal smoking indicates pregnant women who reported tobacco use within the past 30 days and were not exposed to second hand smoke at work and/or at home. Weighted % shows the column percent. Chi-Square, p-values are shown for either Rao-Scott Modified Chi-Square or Wald Chi-Square Tests (e.g. SHS exposed vs. Not Exposed in the sixth column, and Maternal Smoking vs. Not Exposed in the last column). Unmarried includes: widowed, divorced, separated, and never married categories. At least bachelor's degree includes: Bachelor's and Advanced Degree categories.

* indicates statistical significance at a p-value ≤ 0.05.

Table 3
Logistic regression models predicting SHS exposure during pregnancy.

	Unadjusted models		Adjusted, step-wise ordinal logistic regression models			
			Model 1	Model 2	Model 3	Model 4
	OR (95% CI)		OR (95% CI) N = 235	OR (95% CI) N = 234	OR (95% CI) N = 170	OR (95% CI) N = 170
Sociodemographic factors						
Gestation: 1st trimester	1.2 (0.6, 2.2)	1.3 (0.4, 3.9)	1.0 (0.3, 3.2)	1.3 (0.4, 3.8)	1.1 (0.4, 3.3)	
Gestation: 2nd trimester	0.8 (0.4, 1.5)	0.8 (0.3, 2.2)	0.8 (0.3, 2.2)	0.4 (0.1, 1.4)	0.4 (0.1, 1.2)	
Gestation: 3rd trimester	Reference	Reference	Reference	Reference	Reference	
Age: 18 to 24 years	2.2 (1.4, 6.5)*	1.7 (0.7, 4.2)	1.6 (0.7, 4.1)	4.1 (1.3, 12.8)*	3.6 (1.1, 11.6)*	
Age: 25 to 54 years	Reference	Reference	Reference	Reference	Reference	
Marital status: unmarried	2.1 (1.0, 4.2)*	1.7 (0.8, 3.8)	1.8 (0.8, 3.9)	2.4 (0.9, 6.3)	2.7 (1.0, 7.3)*	
Marital status: now married	Reference	Reference	Reference	Reference	Reference	
Race/ethnicity: Black	1.0 (0.5, 1.9)	0.5 (0.2, 1.4)	0.5 (0.2, 1.4)	0.4 (0.1, 1.5)	0.4 (0.1, 1.6)	
Race/ethnicity: Other	1.0 (0.4, 2.4)	1.2 (0.4, 4.3)	1.1 (0.3, 4.2)	4.2 (0.8, 21.1)	4.6 (0.9, 23.4)	
Race/ethnicity: White	Reference	Reference	Reference	Reference	Reference	
Education: < high school	2.2 (0.9, 5.5)	0.5 (0.1, 1.7)	0.4 (0.1, 1.7)	0.7 (0.1, 4.9)	1.2 (0.1, 9.3)	
Education: high school diploma/GED	2.7 (1.2, 6.1)*	2.0 (0.5, 7.9)	1.7 (0.4, 6.9)	5.0 (1.0, 25.9)*	5.4 (1.0, 28.8)*	
Education: some college	2.0 (1.0, 4.1)*	1.1 (0.4, 3.3)	1.1 (0.3, 3.3)	4.4 (1.0, 19.3)*	5.1 (1.1, 23.4)*	
Education: bachelor's/advanced degree	Reference	Reference	Reference	Reference	Reference	
Smoke-free home policies						
Combustible tobacco use: allows	6.8 (3.1, 14.9)*		4.2 (1.1, 16.0)*	4.5 (1.2, 17.0)*	6.3 (1.5, 26.1)*	
Combustible tobacco use: does not allow	Reference		Reference	Reference	Reference	
Noncombustible tobacco use: allows	1.6 (0.9, 3.0)		0.8 (0.2, 2.6)	1.4 (0.4, 4.6)	1.1 (0.3, 3.9)	
Noncombustible tobacco use: does not allow	Reference		Reference	Reference	Reference	
Peer/family approval of tobacco use						
Others' views on tobacco use: positive	5.3 (1.6, 17.8)*			5.1 (0.8, 31.6)	4.9 (0.7, 32.6)	
Others' views on tobacco use: neutral	4.0 (2.1, 7.8)*			0.8 (0.3, 2.3)	0.9 (0.3, 2.6)	
Others' views on tobacco use: negative	Reference			Reference	Reference	
Disapproval of cigarettes: no	3.1 (1.4, 7.0)*			0.9 (0.3, 3.0)	0.9 (0.3, 2.8)	
Disapproval of cigarettes: yes	Reference			Reference	Reference	
Self-reported health perceptions						
Physical health: fair/poor	1.7 (0.6, 4.6)				0.3 (0.0, 2.0)	
Physical health: excellent/very good/good	Reference				Reference	
Mental health: fair/poor	1.9 (0.9, 4.0)				3.0 (0.9, 10.3)	
Mental health: excellent/very good/good	Reference				Reference	

Note: Due to insufficient sample size, measures for smoke-free home policies regarding combustible and non-combustible tobacco products were not included in these analyses. Model 1 includes SES factors only; Model 2 includes Model 1 + Smoke-free home policies; Model 3 = Model 2 + Peer/family approval of tobacco use; Model 4 = Model 3 + Self-reported health perceptions. Marital status: unmarried includes widowed, divorced, separated, and never married categories.

* indicates statistical significance at a p-value ≤ 0.05 .

3.2. Sociodemographic characteristics across tobacco exposure

Among the group of women who were categorized as being SHS exposed during pregnancy, 54.5% indicated living with someone who uses combustible tobacco products, 38.8% indicated that they were exposed to smoke exposure at work, and 6.7% were exposed to both. When asked “how recently someone smoked around you while at work”, 4.4% responded with ‘today’, 12.8% responded with ‘in the past week’, 4.4% responded with ‘in the past two weeks’, 5.8% responded with ‘in the past month’, and 72.5% indicated either ‘never’, ‘longer than a month ago but within the past year’, or ‘more than a year ago’.

Within the group of pregnant women who reported maternal smoking during pregnancy, most reported cigarette use (88.3%), while the remaining reported e-cigarette use (23.6%), hookah use (9.2%), cigar use (8.3%), smokeless tobacco products (5.2%), pipe tobacco (2.8%), snus (1.4%) and dissolvable tobacco use (0.5%). About 69.6% of mothers who reported smoking during pregnancy used cigarettes only and 30.4% used cigarettes in combination with another tobacco product, suggesting that a majority of women who smoke during pregnancy are using cigarettes.

Tobacco exposure categories by trimester of pregnancy, age at interview, marital status, education level, as shown in Table 1. Compared to women who were not exposed to tobacco smoke during pregnancy, pregnant women exposed to SHS only were more likely to report: younger age, being unmarried, and having lower levels of education.

Using the same reference group, women who reported MSDP only were more likely to report being unmarried and have lower levels of education. Women who reported both MSDP and SHS exposure were more likely to be in their first trimester of pregnancy, younger in age, unmarried, and have lower levels of education.

Tobacco exposure categories by other factors influencing tobacco exposure (e.g. smoke-free home policies, peer/family approval of tobacco, and health-related perceptions) are shown in Table 2. Compared to women who were not exposed to smoke during pregnancy, pregnant women who reported MSDP only were more likely to: allow combustible and non-combustible tobacco use within the home, report that others viewed tobacco positively, and report fair/poor physical and mental health.

3.3. Factors influencing SHS exposure during pregnancy

As shown on Table 3, SHS exposure was significantly associated with age, marital status, education, and allowing combustible tobacco use within the home. Compared to those aged 25 to 54 years, those aged 18 to 24 years were more likely to be SHS exposed (OR = 3.6, 95% CI: 1.1, 11.6). Compared to pregnant women who were married, unmarried pregnant women were more likely to be exposed to SHS (OR = 2.7, 95% CI: 1.0, 7.3). Compared to pregnant women who had obtained a bachelor's or advanced degree, pregnant women who received a high school diploma/GED (OR = 5.4, 95% CI: 1.0, 28.8) and some college

Table 4
Logistic regression models predicting maternal smoking during pregnancy.

	Unadjusted models	Adjusted, step-wise ordinal logistic regression models			
		Model 1	Model 2	Model 3	Model 4
	OR (95% CI)	OR (95% CI) N = 144	OR (95% CI) N = 144	OR (95% CI) N = 109	OR (95% CI) N = 109
Sociodemographic factors					
Gestation: 1st trimester	Reference	Reference	Reference	Reference	Reference
Gestation: 2nd trimester	0.6 (0.3, 1.4)	1.4 (0.2, 8.9)	1.4 (0.2, 12.1)	0.5 (0.1, 3.2)	0.3 (0.0, 2.6)
Gestation: 3rd trimester	0.8 (0.3, 1.7)	0.8 (0.2, 3.9)	0.8 (0.1, 6.7)	0.3 (0.0, 2.7)	0.2 (0.0, 2.2)
Age: 18 to 24 years	Reference	Reference	Reference	Reference	Reference
Age: 25 to 54 years	1.5 (0.8, 2.8)	5.9 (1.7, 20.1)*	6.9 (1.7, 27.2)*	2.3 (0.5, 10.7)	4.7 (0.5, 41.6)
Marital status: now married	Reference	Reference	Reference	Reference	Reference
Marital status: unmarried	5.8 (1.9, 17.8)*	11.7 (3.0, 45.9)*	20.8 (0.9, 112.2)*	6.7 (1.0, 44.3)*	11.5 (1.1, 118.3)*
Race/ethnicity: White	Reference	Reference	Reference	Reference	Reference
Race/ethnicity: Black	1.5 (0.7, 3.3)	3.2 (0.7, 15.2)	1.6 (0.4, 6.7)	1.6 (0.3, 7.9)	2.0 (0.3, 13.4)
Race/ethnicity: Other	1.6 (0.4, 6.5)	1.9 (0.4, 8.9)	1.7 (0.2, 13.4)	0.2 (0.0, 12.8)	0.7 (0.0, 52.2)
Education: < high school	Reference	Reference	Reference	Reference	Reference
Education: high school diploma/GED	0.7 (0.3, 1.7)	2.0 (0.6, 7.3)	1.7 (0.3, 8.9)	1.0 (0.1, 7.8)	1.2 (0.1, 10.9)
Education: some college	0.5 (0.2, 1.1)	0.7 (0.2, 3.0)	0.7 (0.1, 3.8)	0.4 (0.1, 2.8)	0.2 (0.0, 1.5)
Smoke-free home policies					
Combustible tobacco: does not allow	Reference	Reference	Reference	Reference	Reference
Combustible tobacco: allows	11.6 (4.7, 28.5)*	22.2 (4.2, 116.8)*	50.5 (7.0, 364.4)*	26.3 (4.6, 150.8)*	26.3 (4.6, 150.8)*
Non-combustible tobacco: does not allow	Reference	Reference	Reference	Reference	Reference
Non-combustible tobacco: allows	2.1 (1.0, 4.3)*	1.0 (0.2, 6.8)	0.9 (0.1, 6.3)	1.6 (0.2, 14.1)	1.6 (0.2, 14.1)
Peer/family approval of tobacco use					
Others' views on tobacco use: positive	Reference	Reference	Reference	Reference	Reference
Others' views on tobacco use: neutral	0.9 (0.2, 3.8)			0.4 (0.0, 5.6)	0.6 (0.1, 6.9)
Others' views on tobacco use: negative	0.8 (0.2, 3.0)			1.1 (0.1, 13.1)	1.8 (0.2, 21.2)
Disapproval of cigarettes: no	Reference			Reference	Reference
Disapproval of cigarettes: yes	1.1 (0.3, 4.2)			2.0 (0.5, 8.1)	4.0 (0.8, 21.2)
Self-reported health perceptions					
Physical health: excellent/very good/good	Reference				Reference
Physical health: fair/poor	3.7 (1.5, 9.0)*				0.2 (0.0, 1.6)
Mental health: excellent/very good/good	Reference				Reference
Mental health: fair/poor	5.5 (2.5, 12.1)*				16.5 (1.9, 144.3)*

Note: Model 1 includes SES factors only; Model 2 includes Model 1 + Smoke-free home policies; Model 3 = Model 2 + Peer/family approval of tobacco use; Model 4 = Model 3 + Self-reported health perceptions. Marital status: unmarried includes widowed, divorced, separated, and never married categories. In these models, the category under education ("bachelors/advanced") was removed due to inadequate sample size.

* indicates statistical significance at a p-value ≤ 0.05 .

(OR = 5.1, 95% CI: 1.1, 23.4) were more likely to be exposed to SHS. Pregnant women who allowed combustible tobacco use within the home were more likely to be exposed to SHS, compared to pregnant women who did not allow combustible tobacco use within the home (OR = 6.3, 95% CI: 1.5, 26.1).

3.4. Factors influencing maternal smoking during pregnancy

As shown on Table 4, MSDP was significantly associated with marital status, allowing combustible tobacco within the home, and reporting fair/poor mental health. Unmarried pregnant women are more likely to report MSDP, compared to married pregnant women (OR = 11.5, 95% CI = 1.1, 118.3). Additionally, pregnant women who allow combustible tobacco within the home are more likely to report MSDP, relative to pregnant women who do not (OR = 26.3, 95% CI = 4.6, 150.8). Reporting fair/poor mental health was associated with increased odds of maternal smoking during pregnancy, relative to pregnant women reporting excellent/very good/good mental health (OR = 16.5, 95% CI = 1.9, 144.3).

3.5. Factors influencing maternal smoking & SHS exposure during pregnancy

As shown on Table 5, MSDP and SHS exposure was significantly associated with gestation, marital status, allowing combustible tobacco within the home, and other's views on tobacco use. Unmarried pregnant

women were more likely to report MSDP and SHS exposure, compared to married pregnant women (OR = 3.5, 95% CI = 1.0, 12.1). Pregnant women who allow combustible tobacco within the home were more likely to report both MSDP and SHS exposure, relative to pregnant women who did not allow combustible tobacco within the home (OR = 4.3, 95% CI = 1.8, 24.2). Compared to pregnant women who report that other's views on tobacco use are negative, pregnant women who report that others' views on tobacco use are positive (OR = 22.7, 95% CI = 3.4, 150.2) or neutral (OR = 3.6, 95% CI: 1.0, 12.9) were more likely to report MSDP and SHS exposure.

4. Discussion

Given US fertility rates (Monte and Ellis, 2014), > 26,400 children are likely exposed to some level of tobacco smoke or nicotine exposure during the fetal period. Since the public health burdens and consequences of this issue are high, it is important to identify potential risk factors for smoke exposure during pregnancy. While greater attention has been paid to identifying risk factors for maternal smoking, this study sought to identify social determinants of maternal smoking during pregnancy and SHS exposure among non-smoking pregnant women in the PATH Study. Factors associated with maternal smoking differed from those associated with SHS exposure among non-smoking pregnant women. Specifically, exposure to SHS only was associated with age, marital status, education, and allowance of combustible tobacco use within the home. Meanwhile, MSDP only was associated with

Table 5
Logistic regression models predicting maternal smoking & SHS exposure during pregnancy.

	Unadjusted models	Adjusted, step-wise ordinal logistic regression models			
		Model 1	Model 2	Model 3	Model 4
	OR (95% CI)	OR (95% CI) N = 227	OR (95% CI) N = 225	OR (95% CI) N = 180	OR (95% CI) N = 180
Sociodemographic factors					
Gestation: 1st trimester	1.9 (1.1, 3.5)*	5.0 (1.7, 14.3)*	5.6 (1.8, 17.9)*	6.4 (1.5, 27.9)*	6.5 (1.5, 28.3)*
Gestation: 2nd trimester	0.9 (0.5, 1.7)	2.2 (0.8, 5.8)	1.8 (0.6, 5.5)	1.5 (0.4, 5.7)	1.5 (0.4, 5.7)
Gestation: 3rd trimester	Reference	Reference	Reference	Reference	Reference
Age: 18 to 24 years	2.4 (1.5, 3.7)*	1.0 (0.4, 2.5)	1.0 (0.4, 2.9)	2.8 (0.7, 11.8)	2.7 (0.6, 11.7)
Age: 25 to 54 years	Reference	Reference	Reference	Reference	Reference
Marital status: unmarried	5.8 (2.8, 12.0)*	4.4 (1.7, 11.2)*	3.9 (1.4, 11.4)*	3.4 (1.0, 11.8)*	3.5 (1.0, 12.1)*
Marital status: now married	Reference	Reference	Reference	Reference	Reference
Race/ethnicity: Black	0.9 (0.5, 1.8)	0.5 (0.2, 1.3)	0.3 (0.1, 1.8)	0.8 (0.2, 2.8)	0.8 (0.2, 3.0)
Race/ethnicity: Other	0.5 (0.2, 1.2)	0.5 (0.1, 2.0)	0.8 (0.1, 4.3)	1.3 (0.2, 10.2)	1.4 (0.2, 11.1)
Race/ethnicity: White	Reference	Reference	Reference	Reference	Reference
Education: < high school	8.1 (3.1, 21.2)*	4.9 (1.2, 20.0)*	3.4 (0.6, 18.0)	1.0 (0.1, 7.7)	1.1 (0.1, 9.0)
Education: high school diploma/GED	7.9 (3.3, 19.1)*	9.4 (2.6, 34.5)*	6.9 (1.2, 38.4)*	5.8 (0.9, 24.2)	6.1 (0.8, 24.2)
Education: some college	4.2 (1.8, 9.7)*	2.4 (0.6, 9.6)	2.4 (0.4, 13.8)	1.3 (0.2, 9.5)	1.4 (0.2, 10.9)
Education: bachelor's/advanced degree	Reference	Reference	Reference	Reference	Reference
Smoke-free home policies					
Combustible tobacco: allows	27.6 (13.9, 55.0)*		8.1 (2.1, 31.4)*	7.5 (1.9, 29.3)*	4.3 (0.8, 24.2)*
Combustible tobacco: does not allow	Reference		Reference	Reference	Reference
Non-combustible tobacco: allows	7.1 (1.2, 12.0)*		3.3 (0.9, 12.1)	4.6 (0.9, 24.2)	0.2 (0.0, 1.2)
Non-combustible tobacco: does not allow	Reference		Reference	Reference	Reference
Peer/family approval of tobacco use					
Others' views on tobacco use: positive	10.8 (3.6, 32.1)*			23.2 (3.7, 144.7)*	22.7 (3.4, 150.2)*
Others' views on tobacco use: neutral	6.1 (3.4, 11.1)*			3.7 (1.1, 13.0)*	3.6 (1.0, 12.9)*
Others' views on tobacco use: negative	Reference			Reference	Reference
Disapproval of cigarettes: no	1.2 (0.5, 2.6)			0.2 (0.1, 1.2)	0.3 (0.1, 1.2)
Disapproval of cigarettes: yes	Reference			Reference	Reference
Self-reported health perceptions					
Physical health: fair/poor	2.7 (1.3, 5.8)*				0.8 (0.1, 5.9)
Physical health: excellent/very good/good	Reference				Reference
Mental health: fair/poor	3.3 (1.8, 6.0)*				1.5 (0.3, 8.1)
Mental health: excellent/very good/good	Reference				Reference

NOTE: Model 1 includes SES factors only; Model 2 includes Model 1 + Smoke-free home policies; Model 3 = Model 2 + Peer/family approval of tobacco use; Model 4 = Model 3 + Self-reported health perceptions. Marital status: unmarried includes widowed, divorced, separated, and never married categories.

* indicates statistical significance at a p-value ≤ 0.05 .

marital status, allowance of combustible tobacco use within the home, and mental health status. Reports of both MSDP and SHS exposure were associated with trimester of pregnancy, marital status, allowance of combustible tobacco use within the home, and others' perceived views on tobacco.

To date, only a limited number of studies have attempted to characterize the source of SHS exposure among non-smoking pregnant women, with a majority of these studies being conducted internationally, within low-income countries. Findings from these studies indicate that the primary source of SHS exposure for many non-smoking women is spouses who smoke within the home (Yoo et al., 2010; Becher et al., 1992; Riboli et al., 1990). Given that extended families or multi-generational families may be living within the same home, interventions will need to address all potential smokers within the home. However, most interventions focus on reducing SHS exposure through partners or husbands who smoke (Tong et al., 2015). One effective means to reduce SHS exposure among pregnant women (and increase smoking cessation among family members) is to implement smoke-free homes. According to one systematic review considering the efficacy of clinical interventions to reduce smoke exposure among non-smoking pregnant women (Tong et al., 2015), low-self efficacy in enforcing the existence of a smoke-free home and shame in asking guests not to smoke are the two main barriers to women establishing smoke-free homes. This might be tied to some settings, where gender roles and empowerment may be a barrier (Kazemi et al., 2011; Lee, 2008). Interventions may need to focus some attention to empowerment and

negotiation skills among pregnant women who want to reduce smoke exposure at home.

Smoke exposure is not limited to the home, however. Working women of reproductive age in the US might also be exposed to SHS at work. Thus, these results have the potential to inform workplace policies for pregnant women and should be an area of study for future research. Those at highest risk of SHS exposure at work are those who work in accommodations and food services industries (e.g. hotels, restaurants, bars), which might be attributed to the fact that many states' smoke free laws do not cover these industries. Other studies have found that lower-SES women (e.g. are less educated and have lower annual household incomes) are at higher risk of SHS exposure, even in the presence of smoke-free policies within the workplace (Anon., n.d.). According to a recently published review of the literature, women with lower SES may be at higher risk for SHS exposure because of: limited capacity to manage smoke exposure; need for relief from stressors; increased vulnerability to tobacco use, leading to anticipatory smoking within the home in response to smoking restrictions within the workplace; and, heightened stigmatization following the implementation of smoking restrictions (Greaves and Hemsing, 2009). These findings suggest that it is important to develop policies and programs that are designed to support women who may have limited resources to be smoke-free, such as the implementation of cessation programs targeting women, their partners, families, and friends that complement smoke-free bans within the workplace (Greaves and Hemsing, 2009). Results from our analyses did not yield significant associations between SHS exposure

and level of education, unlike previously conducted studies on SHS in pregnant women (Anon., n.d.; Hawkins et al., 2014; Aurrekoetxea et al., 2014; Norsa'adah and Salinah, 2014; Jhun et al., 2010). Rather, similar to other previously conducted studies (Aurrekoetxea et al., 2014; Polanska et al., 2016; Hikita et al., 2017), we found that SHS exposure was associated younger age and income. We also identified two novel factors related to SHS exposure among pregnant women: trimester of pregnancy and views on tobacco of people who are important to them. More research is needed to investigate these associations.

The findings of this study must be considered within the context of certain limitations. Findings were based upon self-reported measures, which have the potential to introduce both recall and social desirability biases. Additionally, one review paper finds that self-reported measures of hours of women's smoke exposure at home and cigarettes smoked per day at home are not reliable measures of smoke exposure when compared to cotinine levels (e.g. a nicotine metabolite, commonly used for assessing smoke exposure) measured from cord blood (Avila-Tang et al., 2013). Previous studies suggest that at least a third of pregnant women who report non-smoking have serum cotinine levels indicative of smoke exposure (e.g. > 0.05 ng/ml) (Hawkins et al., 2014; Centers for Disease Control and Prevention (CDC), 2010; Schechter et al., 2018), suggesting that perhaps the prevalence and the amount of smoke exposure experienced by non-smoking pregnant women within our sample is potentially underestimated.

5. Conclusions

Pregnant women should be a priority population for tobacco control efforts within the US, given how common smoke exposure is within this population. Our study identified factors influencing maternal smoking and SHS exposure during pregnancy. Results suggest that the social determinants influencing MSDP, SHS exposure, and MSDP paired with SHS exposure are different, but overlapping. Women at risk for any smoke exposure during pregnancy include those who are unmarried and allow the use of combustible tobacco products within the home. Those who are at higher risk for SHS exposure include those who are younger in age, and those who are earlier in their pregnancy. Those who are at higher risk for maternal smoking include those with fair/poor mental health status and those who believe that others' view tobacco use more positively. These different, but overlapping, risk factors suggest that a more comprehensive approach is needed to protect pregnant women from exposure to tobacco smoke at the level of maternal smoking and SHS exposure at work and at home. Thus, to reap the greatest benefit, smoke-free policies that change social norms regarding tobacco use should be paired with cessation assistance and mental health promotion among this vulnerable population.

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Declaration of interests

The authors report no conflicts of interest.

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