



## Examining the relationship between pregnancy and quitting use of tobacco products in a U.S. national sample of women of reproductive age

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### ABSTRACT

This study examined quit rates longitudinally for cigarettes, e-cigarettes, hookah, cigars, and all tobacco products in a U.S. national sample of women aged 18–44 who completed both Wave 1 (W1) and Wave 2 (W2) of the Population Assessment of Tobacco and Health (PATH, 2013–2014, 2014–2015) study ( $N = 7814$ ). Quit rates were examined among women who transitioned into pregnancy across survey waves, and among a comparable sample of non-pregnant women to provide contextual information about quitting among the broader population of reproductive-aged women. Multiple logistic regression modeling was used to estimate the associations of pregnancy and quitting adjusting for other demographic and psychosocial characteristics. Quit rates among women who were pregnant in W2 were highest for hookah (98.3%), followed by cigars (88.0%), e-cigarettes (81.3%), and lowest for tobacco cigarettes (53.4%). Slightly more than half (58.7%) of women reported quitting use all tobacco products while pregnant. Pregnancy was independently associated with increased odds of quitting hookah (AOR = 52.9, 95%CI = 3.4, 830.2), e-cigarettes (AOR = 21.0, 95%CI = 2.6, 170.3), all tobacco products (AOR = 9.6, 95%CI = 6.4, 14.5), and cigarettes (AOR = 6.5, 95%CI = 4.2, 10.1), although not cigars. Relative to other demographic and psychosocial characteristics, pregnancy was the strongest predictor of quitting use of each tobacco product. While these data indicate that pregnancy has strong, independent associations with quitting a variety of commercially available tobacco products, the comparatively lower quit rates for cigarettes versus other tobacco products underscores the long-standing need for more intensive, multi-pronged clinical and regulatory interventions to reduce cigarette use among reproductive-aged women.

### 1. Introduction

Understanding tobacco use among reproductive-aged women is critically important due to the adverse perinatal outcomes associated with use should they become pregnant. Tobacco use during pregnancy is associated with pregnancy complications, growth retardation, premature delivery, stillbirth, and sudden infant death syndrome (Halpern-Felsher and Orrell-Valente, 2007; Cnattingius, 2004; Dietz et al., 2010;

Pauly and Slotkin, 2008). Not surprisingly, changes in cigarette smoking during pregnancy are of considerable interest (Heil et al., 2014; Morasco et al., 2006; Solomon and Quinn, 2004; Tong et al., 2013). To our knowledge, the most recent estimate of quit rates during pregnancy in the U.S. was 55% in 2011 based on data from 24 states in the Center for Disease Control and Prevention's (CDC) Pregnancy Risk Assessment Monitoring System (CDC, 2018). However, whether that quit rate has changed since 2010 and how it extends to other tobacco

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products is unclear. Addressing this knowledge gap on quit rates for cigarettes is important considering the well documented adverse effects noted above, but newer products like e-cigarettes are also of concern as nicotine alone is a potential teratogen that penetrates the placental barrier and may have neurotoxic effects and impair fetal pulmonary development (England et al., 2015; van der Eijk et al., 2017). Recent years have seen considerable increases in alternative tobacco use among U.S. youths and adults (Arrazola et al., 2014), including increases in e-cigarette use from 1.5% to 16.0% among U.S. high school students between 2011 and 2015, and increases in hookah use from 4.1% to 7.2% over these same years (Singh et al., 2016). Reproductive-aged women (15–44 yrs) are included among the groups using these products, thereby raising questions about the extent to which women quit using them during pregnancy. To our knowledge, no prior study has explicitly examined quit rates associated with pregnancy in a U.S. national sample across a range of commercially available tobacco products, which is the purpose of the present study.

Existing literature on tobacco use among women of reproductive age has reported on topics including prevalence of cigarette smoking and alternative tobacco product use (Alshaarawy and Anthony, 2015; Brown et al., 2016), risk factors for tobacco use (Chivers et al., 2016; Hand et al., 2014; Vubric et al., 2015), and changes in conventional cigarette smoking upon learning of pregnancy (Heil et al., 2014; Solomon and Quinn, 2004; Tong et al., 2013). Those studies that have examined these research questions among U.S. national samples have primarily used the National Survey on Drug Use and Health (NSDUH), which is cross-sectional rather than longitudinal and, until very recently, excluded e-cigarettes. More recently, a series of studies have examined prevalence and correlates of tobacco use among non-pregnant women of reproductive age (Lopez et al., under review) and pregnant women (Kurti et al., 2017) utilizing the first wave of the Population Assessment of Tobacco and Health (PATH; 2013–2014) study. Although these cross-sectional studies comparing prevalence of individual product use among non-pregnant and pregnant samples provide some initial data about how pregnancy may impact quitting, this research question would be better addressed using longitudinal rather than cross-sectional methods. At least one study has examined longitudinal changes in patterns of single, dual, and poly tobacco use over time among women who completed both Wave 1 (W1) and Wave 2 (W2; 2014–2015) of the PATH study (Kurti et al., under review), however, the overarching focus in that report was on poly-tobacco use patterns over time precluding an examination of quit rates across individual tobacco products during pregnancy.

The present study extends prior reports by conducting an explicit examination of the association of pregnancy and quit rates across individual commercially available tobacco products, compared to quit rates over that same time period among women who did not become pregnant in a national sample of U.S. women. We examined this question using the four most prevalent products among reproductive-aged women in the aforementioned reports (Kurti et al., 2017; Lopez et al., under review). We first assessed W1 prevalence of cigarette, e-cigarette, hookah, cigar, and any tobacco use, as well as the proportion of women using each product in W1 who reported no current use of that product in W2, among (a) women not pregnant in W1 and pregnant in W2 of the PATH study, and (b) women not pregnant in either wave. To further refine our estimates of associations between pregnancy and quitting across each product, we conducted multiple logistic regression analyses in which pregnancy was included as an independent variable in models adjusting for other demographic and psychosocial characteristics associated with quitting tobacco use.

## 2. Method

### 2.1. Data source

Data were obtained from the public use files of the first and second

waves of the PATH study, a nationally representative study of the U.S. non-institutionalized population aged  $\geq 12$  years ( $N = 45,971$ , Adult  $N = 32,320$ ) (Hyland et al., 2017; Kasza et al., 2017). Data from W1 were collected between September 2013 and December 2014 using address-based, area-probability sampling. W2 data were collected between October 2014 and October 2015. This report is limited to women aged 18–44 years in W1 who also provided information in W2. Weighting procedures adjusted for varying selection probabilities and differential non-response rates using a combination of census data and person-level data collected during the household screening interview, while appropriately accounting for the complex study design. The overall weighted response rate for W1 for adults was 74.0% with a weighted retention rate of 83.1% at W2. Non-responders were more likely to be older ( $p = 0.01$ ), non-Hispanic White ( $p = 0.03$ ), and living at or above the poverty level ( $p = 0.006$ ) than responders. They did not, however, differ with respect to education, U.S. census region, alcohol or drug use, or use of any of the tobacco products examined. The analyses described below were conducted among women not pregnant in W1 and pregnant in W2 ( $n = 332$ , weighted % = 3.6, 95%CI = 3.1, 4.1), and women not pregnant in either wave ( $n = 7482$ , weighted % = 96.4, 95%CI = 95.9, 96.9). Among women who were pregnant at the time they completed the W2 survey, the average gestational age (in weeks) was 20.7 (95%CI = 19.2, 22.2; range = 1–41 weeks).

### 2.2. Measures

#### 2.2.1. Sociodemographics

Sociodemographic data examined included age, race/ethnicity, education, U.S. census region, and poverty status.

#### 2.2.2. Pregnancy

At W1, female respondents  $< 50$  years of age were asked if they had ever been pregnant, while the W2 version of this question asked about pregnancy in the previous 12 months. Women who responded affirmatively to this question received a second question asking if they were currently pregnant, and if yes, they were asked to self-report their gestational age. Women who endorsed being pregnant at the time they completed the W2 survey were identified as pregnant in this report, while women endorsing current pregnancy at W1 were removed from all analyses. Questions regarding pregnancy were asked near the end of the survey, after assessments of tobacco, alcohol and other substance use, and psychiatric status.

#### 2.2.3. Tobacco product use categories

For all tobacco products, respondents were identified as current established or current experimental users according to the PATH pre-defined tobacco use categories (Hyland et al., 2017). These variable definitions (see Supplementary Table 1) were developed based on well-established national surveys including the Tobacco Use Supplement to the Current Population Survey, and use of PATH pre-defined tobacco use variables is recommended for the purposes of maintaining consistency and facilitating replication across PATH studies (Kasza et al., 2017). Respondents received the same questions about tobacco use at each survey wave, thus the same definitions were applied in assigning respondents to tobacco use categories in W1 and W2.

For conventional tobacco cigarettes, current established cigarette smokers included respondents who reported smoking  $\geq 100$  lifetime cigarettes and smoking every day or some days at the time of survey completion. Current experimental smokers included respondents who reported smoking  $< 100$  lifetime cigarettes and smoking every day or some days at the time of survey completion.

Respondents were also identified as current established or current experimental users of e-cigarettes, hookah, and any cigar (aggregate category of traditional cigars, filtered cigars, and cigarillos). Current established users of these products included respondents who reported using the product fairly regularly in the past and using some days or

every day at the time of survey completion. Current experimental users reported using the product in the past but not fairly regularly, and using some days or every day at the time of survey completion.

Finally, respondents were identified as current established or current experimental users of any tobacco product in a similar manner. Specifically, established users of any tobacco included respondents who reported using at least one tobacco product fairly regularly in the past and using some days or every day at the time of survey completion. Current experimental users reported no fairly regular use of any tobacco product in the past, but reported using some days or daily at the time of survey completion.

#### 2.2.4. Quitting tobacco product use

For each of the tobacco products above, quitting was defined as being a current user of a product in W1 and a former user of that same product in W2. As with the current use definitions for each product, former use is also a PATH pre-defined tobacco use category to which respondents were assigned if they endorsed past use of a particular product but no use at all at the time of the W2 survey. Thus, the quit rate for a given product refers to the proportion of women who were categorized according to PATH pre-defined variables as current users of a specific product in W1 and former users of that same product in W2.

#### 2.2.5. Other substance use

Alcohol use was defined as any alcohol consumption within the past year. Illicit drug use was defined as using at least one of the following substances in the past year: marijuana, cocaine or crack, prescription drugs like painkillers or sedatives used without a prescription, stimulants like methamphetamine or speed, or any other drugs such as heroin, inhalants, solvents, or hallucinogens.

#### 2.2.6. Psychiatric status

The Global Appraisal of Individual Needs—Short Screener (GAIN-SS; Dennis et al., 2006) is designed to measure possible internalizing and externalizing psychiatric disorders, substance use disorders, and crime/violence problems. We report on two subscales that measure constructs associated with smoking: internalizing (e.g., anxiety, depression) and externalizing (e.g., hyperactivity, impulsivity). Both subscales present respondents with a specific symptom and ask them to identify how recently they experienced that symptom (e.g., past month, past year, never). Respondents received one point for each symptom they endorsed experiencing in the past year, with internalizing and externalizing subscale scores ranging from 0 to 4 and 0 to 5, respectively. Total scores of 0 suggest that respondents are unlikely to have a diagnosis or need services, scores of 1 or 2 indicate a possible diagnosis, and scores  $\geq 3$  indicate high probability of a diagnosis (Chestnut Health Services, 2010).

#### 2.3. Statistical methods

Frequencies and percentages were generated across all respondents and were weighted to account for the complex sampling scheme, sampling probability, and differential non-response. Variance estimation was conducted as a variant of balanced repeated replication (Fay's method) (Judkins, 1990; McCarthy, 1969) using a predetermined value  $\epsilon$  set to 0.3, recommended as the preferred procedure for the PATH study.

We first examined prevalence of current use of cigarettes, hookah, e-cigarettes, cigars, and any tobacco in W1 among (a) women not pregnant in W1 and pregnant in W2 and (b) women not pregnant in either wave. In this report, we present W1 overall prevalence of current use, as well as prevalence of current established and current experimental use, for each product. We then calculated the proportion of current users of each product in W1 who reported no longer using that product at the time they completed the W2 survey. The proportion of women defined as current users of a specific product in W1 who were defined as former

users of that product in W2 represents the one-year quit rate for that product. Use of alternative tobacco products often occurs alongside cigarette smoking (dual or poly-product use) and thus quit rates for alternative products may not reflect quitting all tobacco use (Kurti et al., under review; Wong et al., 2018). Therefore we also calculated a one-year quit rate for use of all tobacco products. As with W1 prevalence estimates, we present quit rates both overall and separately among established and experimental users of each product.

Logistic regression including both subgroups of reproductive-aged women in the same model was used to examine the extent to which quitting tobacco use in W2 was significantly different between those who were pregnant in W2 versus those who were not pregnant in either wave. Five separate analyses were conducted examining quitting cigarettes, e-cigarettes, hookah, cigars, and all tobacco products. Predictors in each regression included pregnancy status, tobacco use status (i.e., established versus experimental user), an interaction term between pregnancy and tobacco use status to determine whether the impact of pregnancy on quitting tobacco use differed among the two current user types, as well as demographic and psychosocial characteristics. These variables were retained in all five regressions to ensure comparability of results across models. Odds ratios in the models represent the odds of quitting the product in question adjusting for all other variables in the final model.

All analyses were conducted using SAS 9.4 software (SAS Institute, Cary, NC) and statistical significance was defined as  $p < 0.05$  (2-tailed). Missing data on any variable resulted in case-wise deletion of that respondent.

### 3. Results

#### 3.1. Sample characteristics

Table 1 shows respondent characteristics (collected in W1) overall and separately within the two subgroups of interest. Slightly over one quarter (27.6%) of respondents were between 18 and 24 years, with the remaining 72.4% between 25 and 44 years. Slightly over half (57.5%) of respondents were White, and approximately a third (32.9%) attained a high school education or less. Similar proportions of respondents were represented across the four U.S. census regions, with a slightly higher proportion from the South (36.8%) and a slightly lower proportion from the Northeast (17.1%). Slightly over a third (34.5%) of respondents lived at or below the federal poverty line. Over two thirds (70.4%) of respondents endorsed past year alcohol use and 20.1% endorsed past year illicit drug use. Average scores on the GAIN internalizing and externalizing scales were 1.4 and 0.8, respectively.

#### 3.2. Tobacco product use and cessation

Table 2 (top) shows prevalence (95%CI) of current use (overall, established use, experimental use) of cigarettes, e-cigarettes, hookah, cigars, and any tobacco in W1 among women not pregnant in W1 and pregnant in W2 (left), and among women not pregnant in either wave (right).

The proportions of current users of each tobacco product in W1 who went on to quit using that product in W2 are also displayed in Table 2 (bottom). Recall that quitting in the present study refers to the proportion of respondents categorized as current users of a given product in W1 who were categorized as former users of that same product in W2. One-year quit rates for each product are displayed overall and separately for established versus experimental users among women who were pregnant in W2 (left) and among women not pregnant in either wave (right).

Among women who became pregnant in W2, overall quit rates for cigarettes, e-cigarettes, hookah, and cigars were 53.4% (95%CI = 43.2, 63.7), 81.3% (95%CI = 59.8, 100.0), 98.3% (95%CI = 94.9, 100.0), and 88.0% (95%CI = 76.4, 99.7), respectively. The rate for quitting all

**Table 1**

Characteristics of females age 18–44 who completed W1 and W2 of the Population Assessment of Tobacco and Health (PATH) Study, United States, 2013–2015.

Characteristic	Overall (n = 7814)	Not pregnant in W1, pregnant in W2 (n = 332)	Not pregnant in either Wave (n = 7482)
	Weighted % (95%CI)	Weighted % (95%CI)	Weighted % (95%CI)
Age			
18–24 years	27.6 (27.3, 28.0)	32.7 (26.7, 38.8)	27.4 (27.0, 27.9)
25–34 years	36.8 (35.3, 38.3)	59.7 (52.5, 66.9)	35.9 (34.4, 37.4)
35–44 years	35.5 (34.1, 37.0)	7.6 (2.8, 12.3)	36.6 (35.1, 38.1)
Race/ethnicity <sup>a</sup>			
Non-Hispanic White	57.5 (56.2, 58.8)	62.2 (54.8, 69.5)	57.3 (56.0, 58.6)
Non-Hispanic Black	12.1 (11.3, 13.0)	10.2 (6.9, 13.6)	12.2 (11.3, 13.1)
Hispanic	21.0 (19.8, 22.1)	22.3 (15.6, 29.0)	20.9 (19.7, 22.1)
Other	9.4 (8.4, 10.3)	5.3 (1.9, 8.7)	9.6 (8.6, 10.5)
Education level			
< High school/GED	13.0 (12.6, 13.4)	14.8 (10.4, 19.3)	12.9 (12.5, 13.5)
High school graduate	19.9 (19.4, 20.3)	22.0 (15.7, 28.4)	19.8 (19.3, 20.3)
Some college/associates degree	36.5 (36.0, 37.0)	31.5 (24.0, 39.0)	36.7 (36.1, 37.2)
Bachelor's/advanced degree	30.7 (30.1, 31.2)	31.6 (23.7, 39.5)	30.6 (30.0, 31.3)
U.S. census region			
Northeast	17.1 (16.2, 18.1)	18.2 (13.4, 23.1)	17.1 (16.1, 18.1)
Midwest	21.3 (19.6, 23.0)	22.5 (17.8, 27.2)	21.3 (19.6, 23.0)
South	36.8 (35.2, 38.5)	37.0 (29.3, 44.7)	36.8 (35.2, 38.5)
West	24.7 (23.2, 26.2)	22.3 (15.8, 28.8)	24.8 (23.3, 26.3)
Poverty status <sup>b</sup>			
Below poverty level	34.5 (33.1, 35.9)	35.4 (28.6, 42.3)	34.5 (33.1, 35.9)
At or above poverty level	65.5 (64.1, 66.9)	64.6 (57.7, 71.4)	65.5 (64.1, 66.9)
Alcohol use <sup>c</sup>			
Yes	70.4 (68.2, 72.6)	71.3 (62.9, 79.7)	70.4 (68.2, 72.5)
No	29.6 (27.4, 31.8)	28.7 (20.3, 37.1)	29.6 (27.5, 31.8)
Illicit drug use <sup>d</sup>			
Yes	20.1 (18.8, 21.4)	26.5 (16.0, 25.2)	20.1 (18.7, 21.4)
No	79.9 (78.6, 81.2)	79.4 (74.8, 84.0)	79.9 (78.6, 81.3)

  

Characteristic	Overall (n = 7814)	Not pregnant in W1, pregnant in W2 (n = 332)	Not pregnant in either Wave (n = 7482)
	Mean (range)	Mean (range)	Mean (range)
Psychiatric status <sup>e</sup>			
Internalizing	1.4 (0.0, 4.0)	1.4 (0.0, 4.0)	1.4 (0.0, 4.0)
Externalizing	0.8 (0.0, 5.0)	0.8 (0.0, 5.0)	0.8 (0.0, 5.0)

<sup>a</sup> The four racial/ethnicity categories (White, Black, Other, Hispanic) are mutually exclusive; persons identifying as Hispanic are categorized as such, regardless of race, “Other” includes non-Hispanic persons of two or more races and persons belonging to racial groups other than non-Hispanic White or non-Hispanic Black.

<sup>b</sup> Based on reported family income and poverty thresholds published by the U.S. Department of Health and Human Services.

<sup>c</sup> Self-reported alcohol use within the past year.

<sup>d</sup> Self-reported use of at least one of the following illicit drugs within the past year: marijuana, cocaine or crack, prescription drugs such as painkillers or sedatives used without a prescription, stimulants like methamphetamine or speed, or any other drugs such as heroin, inhalants, solvents, or hallucinogens.

<sup>e</sup> Represents the average number of symptoms experienced in the past year reflecting a possible internalizing or externalizing psychiatric disorder (score ranges 0 to 4 and 0 to 5, respectively).

tobacco products entirely while pregnant was 58.7% (95%CI = 49.2, 68.2). With the exception of hookah, quit rates were higher among experimental than established users across all products. Among women not pregnant in either wave, overall quit rates for cigarettes, e-cigarettes, hookah, and cigars were 13.9% (95%CI = 12.4, 15.3), 45.0% (95%CI = 40.9, 49.1), 57.3% (95%CI = 53.8, 60.8), and 67.5% (95%CI = 63.4, 71.6), respectively. The rate for quitting all tobacco products entirely was 17.7% (95%CI = 16.4, 19.0). Quit rates were higher among experimental than established users across all products.

### 3.3. Logistic regression modeling

#### 3.3.1. Cigarettes

Table 3 shows results from the regression predicting quitting cigarettes. Those variables that remained independently associated with increased odds of quitting cigarettes included pregnancy, being an experimental versus established smoker, being 18–24 years old versus 35–44 years, having a Bachelor's degree versus all lower levels of educational attainment, and reporting more past year externalizing

symptoms. Pregnancy was the strongest predictor, and the effect of pregnancy on quitting cigarettes did not differ between established versus experimental cigarette smokers (pregnancy-by-use status interaction  $p = 0.82$ ).

#### 3.3.2. E-cigarettes

Significant predictors of quitting e-cigarettes included pregnancy, being an experimental versus established e-cigarette user, and reporting fewer past year externalizing symptoms, with pregnancy being the strongest predictor (Table 3). A statistically significant pregnancy-by-use status interaction ( $p = 0.003$ ) suggests that the effect of pregnancy on quitting differed between established versus experimental e-cigarette users. This is reflected in the differential quit rates presented in Table 2, however the complete absence of experimental users continuing to use e-cigarettes while pregnant precluded the ability to calculate ORs for quitting separately by W1 use status.

#### 3.3.3. Hookah

Significant predictors of quitting hookah included pregnancy, being

**Table 2**

Prevalence of tobacco product use in W1 (Top) and proportion of W1 current users who became former users in W2 (quit rates; Bottom) among females age 18–44 who completed W1 and W2 of the Population Assessment of Tobacco and Health (PATH) Study, United States, 2013–2015.

	Women not pregnant in W1 and pregnant in W2 (n = 332)		Women not pregnant in either W1 or W2 (n = 7482)	
	Prevalence (95%CI)	Weighted N	Prevalence (95%CI)	Weighted N
<b>Wave 1 tobacco product use</b>				
<b>Cigarette</b>				
Overall <sup>a</sup>	23.1 (17.9, 28.4)	451,952	21.4 (20.3, 22.5)	10,716,336
Established use	19.2 (14.5, 23.8)	373,955	17.4 (17.5, 19.4)	9,231,028
Experimental use	4.0 (1.5, 6.4)	77,997	3.0 (2.6, 3.3)	1,485,308
<b>E-cigarette</b>				
Overall <sup>b</sup>	5.2 (2.9, 7.5)	101,431	6.2 (5.7, 6.7)	3,121,298
Established use	2.8 (1.3, 4.3)	53,838	2.7 (2.3, 3.1)	1,350,813
Experimental use	2.4 (1.1, 3.7)	47,592	3.5 (3.2, 3.9)	1,770,485
<b>Hookah</b>				
Overall <sup>c</sup>	7.1 (4.6, 9.7)	138,544	6.8 (6.2, 7.4)	3,098,791
Established use	2.7 (1.3, 4.0)	51,715	2.0 (1.7, 2.3)	1,012,945
Experimental use	4.5 (2.5, 6.4)	86,829	4.8 (4.3, 5.2)	2,385,846
<b>Any cigar</b>				
Overall <sup>d</sup>	6.2 (3.7, 8.8)	122,199	5.0 (4.6, 5.5)	2,524,972
Established use	2.9 (1.5, 4.3)	56,542	2.0 (1.8, 2.3)	1,018,060
Experimental use	3.4 (1.4, 5.3)	65,658	3.0 (2.7, 3.3)	1,506,912
<b>Any tobacco</b>				
Overall <sup>e</sup>	27.6 (21.8, 33.4)	539,213	27.0 (25.7, 28.3)	36,604,695
Established use	21.8 (17.0, 26.7)	426,729	21.4 (20.3, 22.5)	10,719,578
Experimental use	5.8 (2.9, 8.6)	112,484	5.6 (2.1, 6.1)	2,805,716
<b>Proportion of W1 current users who reported no current use in W2</b>				
<b>Cigarette quit rates</b>				
Overall	53.4 (43.2, 63.7)	239,967	13.9 (12.4, 15.3)	1,478,967
Among established users	48.6 (37.5, 59.7)	181,765	11.5 (10.4, 12.9)	1,059,879
Among experimental users	77.4 (56.4, 98.5)	58,202	29.3 (24.6, 34.0)	419,089
<b>E-cigarette quit rates</b>				
Overall	81.3 (59.8, 100.0)	67,179	45.0 (40.9, 49.1)	1,262,712
Among established users	71.2 (38.7, 100.0)	38,348	32.8 (26.8, 38.8)	418,149
Among experimental users	100.0 (100.0, 100.0)	28,832	55.1 (49.9, 60.3)	844,563
<b>Hookah quit rates</b>				
Overall	98.3 (94.9, 100.0)	136,169	57.3 (53.8, 60.8)	1,887,321
Among established users	100.0 (100.0, 100.0)	51,715	45.4 (38.6, 52.2)	459,439
Among experimental users	97.3 (91.9, 100.0)	84,454	62.6 (58.3, 66.9)	1,427,882
<b>Any cigar quit rates</b>				
Overall	88.0 (76.4, 99.7)	107,592	67.5 (63.4, 71.6)	1,698,579
Among established users	83.0 (65.6, 100.0)	46,925	60.6 (54.7, 66.5)	617,029
Among experimental users	92.4 (76.8, 100.0)	60,668	72.2 (66.9, 77.4)	1,081,550
<b>Any tobacco quit rates</b>				
Overall	58.7 (49.2, 68.2)	316,545	17.7 (16.4, 19.0)	2,395,496
Among established users	51.2 (41.3, 61.1)	218,509	10.3 (9.3, 11.4)	259,884
Among experimental users	87.2 (74.1, 100.0)	316,545	45.9 (42.1, 49.6)	1,286,423

Notes. Raw frequencies for use of each product are as follows: <sup>a</sup>n = 135 (pregnant in W2), n = 2870 (not pregnant in W2). <sup>b</sup>n = 31 (pregnant in W2), n = 836 (not pregnant in W2). <sup>c</sup>n = 47 (pregnant in W2), n = 980 (not pregnant in W2). <sup>d</sup>n = 40 (pregnant in W2), n = 745 (not pregnant in W2). <sup>e</sup>n = 160 (pregnant in W2), n = 3654 (not pregnant in W2).

an experimental relative to established hookah user, being 25–34 years old versus 18–24 years, being White relative to Other race/ethnicity, and living in the Midwest or South relative to the Northeast (Table 4). Pregnancy was the strongest predictor of quitting. As with e-cigarettes, a statistically significant pregnancy-by-use status interaction ( $p = 0.004$ ) suggests that the effect of pregnancy on quitting is dependent upon use status in W1. However, the absence of established hookah users continuing to use hookah while pregnant precluded the ability to calculate ORs for quitting separately for these women.

### 3.3.4. Cigars

The only significant predictor of quitting cigars was W1 use status, with experimental users more likely to quit than established users (Table 4).

### 3.3.5. All tobacco use

Variables independently associated with increased odds of quitting all tobacco product use included pregnancy, being an experimental versus established tobacco user in W1, being 18–24 years old versus

35–44 years, being Hispanic versus White, and having a Bachelor's degree versus all lower levels of educational attainment. Pregnancy was the strongest predictor of quitting and did not differ between W1 experimental and established users (pregnancy-by-use status interaction  $p = 0.79$ ) (Table 5).

## 4. Discussion

The present study examined one-year quit rates longitudinally across four separate tobacco products, as well as any tobacco product use, and whether pregnancy independently predicted quitting after adjusting for demographic and psychosocial characteristics. There are four points on which we wish to comment. First, quit rates were lowest for conventional cigarettes in the presence and absence of pregnancy. Among women who were pregnant in W2, overall quit rates were highest for hookah (98.3%), followed by any cigar (98.3%), e-cigarettes (81.3%), and last by conventional cigarettes (53.4%). Among women not pregnant in either wave, overall quit rates were also high for hookah (57.3%), any cigar (67.5%), and e-cigarettes (45.0%) relative to

**Table 3**

Multiple logistic regressions assessing associations of pregnancy with quitting conventional tobacco cigarettes (left) and e-cigarettes (right) adjusting for demographic and psychosocial characteristics among females age 18–44 yrs who completed W1 and W2 of the Population Assessment of Tobacco and Health (PATH) Study, United States, 2013–2015.

	Cigarette smoking			<i>p</i>	E-cigarette use			<i>p</i>
	AOR	95%CI			AOR	95%CI		
Pregnant in W2				< 0.001				0.005
Yes	6.49	4.18	10.08		20.99	2.59	170.29	
No	Reference				Reference			
Use status in W1								< 0.001
Established user	Reference				Reference			
Experimental user	2.91	2.19	3.86		2.92	2.00	4.25	
Age				< 0.001				0.760
18–24 years	2.08	1.50	2.88		1.20	0.73	1.99	
25–34 years	1.22	0.87	1.70		1.14	0.73	1.79	
35–44 years	Reference				Reference			
Race <sup>a</sup>				0.336				0.315
Non-Hispanic White	Reference				Reference			
Non-Hispanic Black	0.95	0.67	1.36		0.93	0.49	1.77	
Hispanic	1.35	0.95	1.91		1.68	0.95	2.98	
Other	1.10	0.63	1.90		1.05	0.52	2.11	
Education				< 0.001				0.315
< High school/GED	0.31	0.20	0.48		1.22	0.58	2.54	
High school graduate	0.36	0.24	0.53		1.32	0.69	2.54	
Some college/associates degree	0.67	0.48	0.93		1.57	0.91	2.69	
Bachelor's/advanced degree	Reference				Reference			
Poverty <sup>b</sup>				0.068				0.312
Below poverty level	Reference				Reference			
At or above poverty level	1.27	0.98	1.65		1.24	0.81	1.91	
U.S. census region				0.056				0.546
Northeast	0.70	0.41	1.18		1.20	0.67	2.16	
Midwest	0.64	0.46	0.89		1.48	0.84	2.60	
South	0.69	0.50	0.96		1.11	0.69	1.79	
West	Reference				Reference			
Substance use								
Past year alcohol use <sup>c</sup>				0.601				0.083
Yes	1.11	0.76	1.61		1.55	0.94	2.54	
No	Reference				Reference			
Past year illicit drug use <sup>d</sup>				0.088				0.028
Yes	0.77	0.57	1.04		1.48	1.04	2.09	
No	Reference				Reference			
Psychiatric status <sup>e</sup>								
Externalizing	1.17	1.04	1.31	0.009	0.80	0.67	0.95	0.013
Internalizing	0.94	0.85	1.04	0.206	1.13	0.97	1.31	0.113

<sup>a</sup> The four racial/ethnicity categories (White, Black, Other, Hispanic) are mutually exclusive; persons identifying as Hispanic are categorized as such, regardless of race, “Other” includes non-Hispanic persons of two or more races and persons belonging to racial groups other than non-Hispanic White or non-Hispanic Black.

<sup>b</sup> Based on reported family income and poverty thresholds published by the U.S. Department of Health and Human Services.

<sup>c</sup> Self-reported alcohol use within the past year.

<sup>d</sup> Self-reported use of at least one of the following illicit drugs within the past year: marijuana, cocaine or crack, prescription drugs such as painkillers or sedatives used without a prescription, stimulants like methamphetamine or speed, or any other drugs such as heroin, inhalants, solvents, or hallucinogens.

<sup>e</sup> Represents the average number of symptoms experienced in the past year reflecting a possible internalizing or externalizing psychiatric disorder (score ranges 0 to 4 and 0 to 5, respectively).

cigarettes (13.9%). These findings may reflect the fact that experimental users are more likely to quit than established users, and a vast majority of cigarette smokers were established rather than experimental smokers. In contrast, the proportions of established versus experimental users of the alternative tobacco products were distributed more evenly with slightly more women engaged in experimental rather than established use of e-cigarettes, hookah, and cigars. This is consistent with research indicating high and increasing rates of experimentation with alternative tobacco products due to misperceptions about safety, attractive flavors, and social appeal (McMillen et al., 2012; Wong et al., 2018). Alternatively, the lower quit rates for cigarettes relative to the alternative products may reflect tobacco use patterns among dual and poly users, where patterns of multiple product use typically involve cigarettes and are relatively unstable, with users often dropping the alternative tobacco product over time and continuing to smoke conventional cigarettes (Kasza et al., 2017; Kurti et al., under review). Lastly, differences in quit rates may reflect differences in the dependence-producing potential of the different products.

Consistent with that possibility, a study among adults who completed W1 of PATH used factor analysis to identify a set of items comprising a single primary latent construct reflecting dependence (Strong et al., 2017). This set of tobacco dependence indicators was then used to rank dependence across users of different products. Conventional cigarette smokers had the highest mean level of tobacco dependence.

Second, results of the regression analyses indicated that pregnancy was independently associated with increased odds of quitting cigarettes, e-cigarettes, hookah, and all tobacco products, and was also the strongest predictor of quitting use of those products. Comparing across models, the increased odds of quitting a particular product due to pregnancy were greatest for hookah (OR = 52.94), followed by e-cigarettes (OR = 20.99), all tobacco products (OR = 9.63), and lowest for conventional tobacco cigarettes (OR = 6.49). The comparatively strong influence of pregnancy on hookah use is consistent with research conducted with pregnant women suggesting concerns about hookah use (Kahr et al., 2015). Effects of pregnancy on hookah use may also be related to hookah smoking as a social activity (Roberts et al., 2017),

**Table 4**

Multiple logistic regressions assessing associations of pregnancy with quitting hookah (left) and any cigar (right) adjusting for demographic and psychosocial characteristics among females age 18–44 yrs who completed W1 and W2 of the Population Assessment of Tobacco and Health (PATH) Study, United States, 2013–2015.

	Hookah use			<i>p</i>	Any cigar use			<i>p</i>
	AOR	95%CI			AOR	95%CI		
Pregnant in W2				0.005				0.064
Yes	52.94	3.38	830.19		2.99	0.94	9.53	
No	Reference				Reference			
Use status in W1				< 0.001				0.006
Established user	Reference				Reference			
Experimental user	2.31	1.53	3.48		1.68	1.16	2.43	
Age				0.011				0.231
18–24 years	0.89	0.39	2.06		1.63	0.90	2.95	
25–34 years	1.80	0.75	4.35		1.15	0.61	2.15	
35–44 years	Reference				Reference			
Race <sup>a</sup>				0.035				0.263
Non-Hispanic White	Reference				Reference			
Non-Hispanic Black	0.64	0.40	1.02		0.72	0.44	1.18	
Hispanic	0.73	0.47	1.12		1.25	0.70	2.24	
Other	0.49	0.29	0.83		1.22	0.48	3.10	
Education				0.111				0.829
< High school/GED	0.44	0.22	0.86		1.22	0.56	2.67	
High school graduate	0.77	0.43	1.36		1.41	0.61	3.28	
Some college/associates degree	0.74	0.48	1.13		1.13	0.54	2.35	
Bachelor's/advanced degree	Reference				Reference			
Poverty <sup>b</sup>				0.695				0.086
Below poverty level	Reference				Reference			
At or above poverty level	1.07	0.76	1.50		1.42	0.95	2.13	
U.S. census region				0.025				0.933
Northeast	0.61	0.37	1.01		0.93	0.39	2.24	
Midwest	1.60	0.97	2.63		0.95	0.47	1.91	
South	1.14	0.76	1.69		0.84	0.44	1.61	
West	Reference				Reference			
Substance use								
Past year alcohol use <sup>c</sup>				0.228				0.862
Yes	0.74	0.46	1.21		1.04	0.64	1.71	
No	Reference				Reference			
Past year illicit drug use <sup>d</sup>				0.896				0.562
Yes	0.98	0.72	1.34		1.14	0.73	1.78	
No	Reference				Reference			
Psychiatric status <sup>e</sup>								
Externalizing	0.90	0.77	1.05	0.172	0.98	0.83	1.16	0.809
Internalizing	1.09	0.97	1.23	0.154	0.92	0.78	1.08	0.309

<sup>a</sup> The four racial/ethnicity categories (White, Black, Other, Hispanic) are mutually exclusive; persons identifying as Hispanic are categorized as such, regardless of race, “Other” includes non-Hispanic persons of two or more races and persons belonging to racial groups other than non-Hispanic White or non-Hispanic Black.

<sup>b</sup> Based on reported family income and poverty thresholds published by the U.S. Department of Health and Human Services.

<sup>c</sup> Self-reported alcohol use within the past year.

<sup>d</sup> Self-reported use of at least one of the following illicit drugs within the past year: marijuana, cocaine or crack, prescription drugs such as painkillers or sedatives used without a prescription, stimulants like methamphetamine or speed, or any other drugs such as heroin, inhalants, solvents, or hallucinogens.

<sup>e</sup> Represents the average number of symptoms experienced in the past year reflecting a possible internalizing or externalizing psychiatric disorder (score ranges 0 to 4 and 0 to 5, respectively).

where the stigma associated with using tobacco during pregnancy may reduce use. The smaller influence of pregnancy on e-cigarette use relative to hookah use may be related to the presence of considerably greater uncertainty about the harms of using e-cigarettes during pregnancy (Kahr et al., 2015) and/or the use of e-cigarettes to reduce or quit smoking cigarettes (Oncken et al., 2017; England et al., 2016). Nonetheless, results of the regression analyses indicate that variance in quit rates for cigarettes, e-cigarettes, hookah, and all tobacco among pregnant women can be attributed at least in part to pregnancy.

Third, the present results have potentially important implications for tobacco control and regulatory science. Regarding tobacco control, many women, especially conventional cigarette smokers, fail to quit when pregnant, underscoring the importance of improving quit rates in this vulnerable population. Although implementing the 5 As is recommended best practices for pregnant women (Fiore et al., 2008; Melvin et al., 2000), only ~6.0% of providers follow-up with pregnant women who report tobacco use (Coleman-Cowger et al., 2014), and even after implementing Medicaid coverage for smoking cessation

counseling < 1.0% of smokers in one U.S. state had claims for counseling (Scheuermann et al., 2017). More emphasis on tobacco cessation in clinical curricula and increased efforts to promote, monitor, and incentivize provider and patient adherence to current guidelines to further decrease tobacco use during pregnancy warrant consideration (Higgins and Solomon, 2016). Tobacco control efforts should also take into account variables in addition to pregnancy that are associated with quitting tobacco in the design and implementation of new cessation treatments targeting reproductive-aged women. Although we focused primarily on exogenous predictors of quitting, research conducted among pregnant women has also identified other predictors of quit attempts (e.g., pregnancy-specific harm beliefs, self-efficacy) that can be targeted and modified in behavioral interventions (Emery et al., 2017; Naughton et al., 2012). Regarding tobacco regulatory science, the finding that quit rates were lowest for cigarettes—the most prevalent, toxic, and dependence-producing product (Strong et al., 2017), provides support for proposals to lower the maximum nicotine content in cigarettes, which would lower addiction severity thereby making it

**Table 5**

Multiple logistic regressions assessing associations of pregnancy with quitting all tobacco product use adjusting for demographic and psychosocial characteristics among females age 18–44 yrs who completed W1 and W2 of the Population Assessment of Tobacco and Health (PATH) Study, United States, 2013–2015.

	All tobacco use			<i>p</i>
	AOR	95%CI		
Pregnant in W2				< 0.001
Yes	9.63	6.42	14.45	
No	Reference			
Use status in W1				< 0.001
Established user	Reference			
Experimental user	5.70	4.49	7.24	
Age				< 0.001
18–24 years	2.15	1.60	2.87	
25–34 years	1.27	0.95	1.71	
35–44 years	Reference			
Race <sup>a</sup>				0.011
Non-Hispanic White	Reference			
Non-Hispanic Black	1.13	0.82	1.57	
Hispanic	1.45	1.10	1.93	
Other	1.76	0.50	1.14	
Education				< 0.001
< High school/GED	0.25	0.17	0.37	
High school graduate	0.32	0.24	0.44	
Some college/associates degree	0.62	0.46	0.84	
Bachelor's/advanced degree	Reference			
Poverty <sup>b</sup>				0.103
Below poverty level	Reference			
At or above poverty level	1.21	0.96	1.52	
U.S. census region				0.424
Northeast	0.75	0.53	1.06	
Midwest	0.90	0.69	1.17	
South	0.88	0.67	1.15	
West	Reference			
Substance use				
Past year alcohol use <sup>c</sup>				0.265
Yes	1.21	0.87	1.68	
No	Reference			
Past year illicit drug use <sup>d</sup>				0.776
Yes	0.96	0.74	1.25	
No	Reference			
Psychiatric status <sup>e</sup>				
Externalizing	1.08	0.97	1.19	0.179
Internalizing	0.95	0.88	1.02	0.134

<sup>a</sup> The four racial/ethnicity categories (White, Black, Other, Hispanic) are mutually exclusive; persons identifying as Hispanic are categorized as such, regardless of race, “Other” includes non-Hispanic persons of two or more races and persons belonging to racial groups other than non-Hispanic White or non-Hispanic Black.

<sup>b</sup> Based on reported family income and poverty thresholds published by the U.S. Department of Health and Human Services.

<sup>c</sup> Self-reported alcohol use within the past year.

<sup>d</sup> Self-reported use of at least one of the following illicit drugs within the past year: marijuana, cocaine or crack, prescription drugs such as painkillers or sedatives used without a prescription, stimulants like methamphetamine or speed, or any other drugs such as heroin, inhalants, solvents, or hallucinogens.

<sup>e</sup> Represents the average number of symptoms experienced in the past year reflecting a possible internalizing or externalizing psychiatric disorder (score ranges 0 to 4 and 0 to 5, respectively).

easier for current smokers to quit (Benowitz et al., 2012; Donny et al., 2015; Hatsukami et al., 2010; Higgins et al., 2017). Recall also that relative to the other tobacco products, cigarette smokers were comprised primarily by established rather than experimental users: Lowering the maximum nicotine content in cigarettes may also have the benefit of reducing the proportion of women who transition from experimental to established use of cigarettes. In addition to reducing the nicotine content in commercial brand cigarettes, graphic warning labels and/or targeted health messaging about tobacco harms that are specific to pregnancy as well as specific to women generally (e.g., cervical

cancer, osteoporosis) (Gadducci et al., 2011; Roth and Taylor, 2001) may increase motivation to quit (Kollath-Cattano et al., 2017; Levis et al., 2014).

Lastly, the present study has several limitations that warrant mention. First, tobacco use status was based on self-report and thus can be expected to include underreporting of tobacco use, especially during pregnancy. Estimates of misclassification of smoking status among U.S. pregnant women due to underreporting is 23–25%, meaning that the estimated quit rate of 53.4% for cigarettes could be closer to 40% or the lower end of the CI's shown in Table 2 for quitting cigarettes (e.g., England et al., 2007; Dietz et al., 2010). Second, the small sample of women who experienced a pregnancy may have reduced the accuracy of the estimates reported and prevented identification of additional associations in the regression analyses. Indeed, the wide confidence intervals surrounding point estimates particularly for the alternative tobacco products indicate that some degree of imprecision was present. The finding that all experimental e-cigarette users and all established hookah users quit using these products during pregnancy may also be an overestimation due to small sample size. Third, women were queried about tobacco use once per wave at the time of the interview, thus tobacco use at that time may not have reflected use throughout the entire wave. Related to this, although we identified “quitting” as transitioning from current use of a particular product in W1 to former use of that product in W2, it is unclear whether women who used a product experimentally at the time of the W1 interview but not at the time of the W2 interview should be characterized as “quitting” that product. The finding that quit rates were generally higher among experimental relative to established users across nearly all products indicates that collapsing the two groups may inflate estimations of quit rates during pregnancy. Thus we recommend that researchers take into account the distinction between the two types of users in citing quit rates associated with pregnancy to avoid diminishing the problem of tobacco use during pregnancy thereby potentially curbing efforts to reduce prenatal tobacco use. If possible, researchers may also consider biologically verifying gestational age, as the broad range observed here including self-reports as low as one week indicates potential misreporting. Finally, we did not examine frequency of use or dependence, thus we cannot draw conclusions about the importance of these factors versus pregnancy and other respondent characteristics.

These limitations notwithstanding, this study provides what to our knowledge are the first estimates of quitting across a variety of commercially available tobacco products among a longitudinal sample of women who transitioned into pregnancy. The finding that quit rates were lowest for cigarettes demonstrates the need for multipronged approaches to reducing cigarette smoking including intensive efforts in the domains of tobacco control and regulatory science. The study also contributed novel information about the impact of pregnancy versus other demographic and psychosocial characteristics on quitting particular tobacco products, as well as the relative impact of pregnancy on quitting some tobacco products versus others. The finding that pregnancy had strong, independent associations with quitting all products examined except cigars suggests that emphasizing effects of tobacco on fetal and infant health in educational and behavioral interventions as well as public health messaging may motivate quitting. In sum, results of the present study complement existing research revealing pregnancy to be a “teachable moment” capable of promoting health-related behavioral change (Squiers et al., 2013), as well as suggesting important considerations for future research, intervention, regulatory policies, and public health campaigns focused on reducing tobacco use among reproductive-aged women.

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## Conflicts of interest

None to declare.

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