Original investigation

Patterns of Single and Multiple Tobacco Product Use Among US Women of Reproductive Age

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Abstract

Introduction: Understanding patterns of single and multiple tobacco product use among reproductive-aged women is critical given the potential for adverse health effects on mother and infant should a woman become pregnant.

Methods: Patterns of tobacco use over a 2-year period were examined among all women (18–44 years) who completed wave 1 (W1) and wave 2 (W2) of the US Population Assessment of Tobacco and Health (PATH, 2013–2014, 2014–2015) Study. We examined the most common patterns of single and multiple tobacco product use in W1, and longitudinal trajectories of women engaged in each of these patterns of use from W1 to W2, among women not pregnant in either wave (*n* = 7480), not pregnant in W1 and pregnant in W2 (*n* = 332), and pregnant in W1 and not pregnant in W2 (*n* = 325).

Results: The most prevalent patterns of tobacco use in W1 among all three subgroups were using cigarettes alone followed by using cigarettes plus e-cigarettes. In all three subgroups, women using multiple products in W1 were more likely to adopt new use patterns in W2 relative to single-product users, with the new patterns generally involving dropping rather than adding products. The majority of multiple product use included cigarettes, and transitions to single product use typically involved dropping the noncigarette product. The most common trajectory among tobacco users transitioning to or from pregnancy was to use cigarettes alone in W2.

Discussion: This study contributes new knowledge characterizing tobacco use patterns across time and reproductive events among reproductive-aged women.

Introduction

Examining patterns of tobacco use among women of reproductive age is critically important due to the potential for serious adverse health effects from use on mother and infant should a woman become pregnant. Pregnant women are highly vulnerable to the byproducts of combusted tobacco and nicotine.[1–4] Cigarette smoking during pregnancy is the leading preventable cause of poor pregnancy outcomes in the United States, including pregnancy complications, stillbirth, and sudden infant death syndrome.[5,6] Smoking also confers other health risks unique to women including early menopause, osteoporosis, and cervical cancer.[7,8] Previous studies have reported on the prevalence of cigarette smoking and alternative tobacco product use among reproductive-aged women,[9,10] risk factors for using tobacco products,[11–13] as well as changes in conventional cigarette smoking upon learning of pregnancy.[14–16] However, none of these studies were longitudinal and those that involved US national samples used the National Survey on Drug Use and Health (NSDUH),[9,10,13] which is cross-sectional and excludes e-cigarettes. Surveillance systems such as the Pregnancy Risk Assessment Monitoring System (PRAMS)[14] permit longitudinal assessments of tobacco use by querying women about their use of cigarettes, e-cigarettes, and hookah before, during, and following pregnancy. However, PRAMS does not obtain data from all states or include the full spectrum of commercially available tobacco products.

Our research group recently reported results from two parallel studies examining prevalence and correlates of tobacco use across a broad range of commercially available tobacco products among nonpregnant women of reproductive age[17] and pregnant women[18] using the first wave of the Population Assessment of Tobacco and Health (PATH, 2013–2014) Study. In both groups of women, prevalence of alternative tobacco products including e-cigarettes, any cigar, and hookah were substantially higher among current cigarette smokers relative to overall prevalence, and regression analyses revealed cigarette smoking to be a strong correlate of using each of these alternative tobacco products. These results indicate the presence of multiple tobacco product use among reproductive-aged women; however, patterns of single versus multiple product use were not explicitly examined in these reports. Moreover, there was no information included on how these patterns may change over time including transitions to and from pregnancy. Thus, the overarching aims of the present study were twofold. First, we sought to identify the most prevalent tobacco products and/or product combinations used among a US national sample of women of reproductive age. Second, leveraging the longitudinal feature of the PATH Study, we sought to examine how these patterns of use change over time and when punctuated by pregnancy.

Examining patterns of single versus multiple tobacco product use and how these patterns change over time among women of reproductive age is important for several reasons. First, emerging research dissociating the impact of the various byproducts of combusted tobacco use documents serious adverse risks of nicotine alone on fetal health (eg, reduced pulmonary and cardiorespiratory function, auditory processing deficits),[1,19,20] thereby raising important questions particularly regarding the use of e-cigarettes alone or in combination with conventional cigarettes.[21] Second, an improved understanding of tobacco use patterns among reproductive-aged women may inform researchers and clinicians about products and/or product combinations beyond cigarettes that should be better targeted in tobacco control and regulatory interventions. Third, as the FDA has authority to regulate the manufacture, marketing, and distribution of tobacco products, an enhanced understanding of tobacco use patterns can inform where regulations or supporting research may be needed to better protect women and infants from the adverse impacts of tobacco use.

In the present report, we identify the most prevalent patterns of single and multiple tobacco product use, and characterize the longitudinal trajectories of women engaged in these patterns of use among (a) women not pregnant in either wave of the PATH Study, (b) women who transition from not pregnant to pregnant, and (c) women who transition from pregnant to not pregnant.

Methods

Data Source

Data were obtained from the Public Use Files of the first and second waves of the PATH Study, a household-based, nationally representative, longitudinal cohort Study of 45 971 youth and adults (aged 18+ years) in the US noninstitutionalized population. Wave 1 (W1) data were collected from September 2013 through December 2014 using address-based, area-probability sampling. Wave 2 (W2) data were collected from October 2014 through 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 nonresponse rates, while appropriately accounting for the complex study design. The overall weighted response rate for W1 was 74.0% with a weighted retention rate of 88.4% at W2. Other reports provide additional details on adult sampling and weighting procedures.[22,23]

We evaluated demographic characteristics and examined prevalence and longitudinal trajectories of tobacco use within the following subgroups of women (W1/W2 pregnancy status): (a) not pregnant/not pregnant (*n* = 7480, weighted % = 92.8, 95% CI = 92.0% to 93.6%), (b) not pregnant/pregnant (*n* = 332, weighted % = 3.6, 95% CI = 3.0% to 4.1%), and (c) pregnant/not pregnant (*n* = 325, weighted % = 3.6, 95% CI = 2.1% to 4.1%). Seventeen women were pregnant in both waves and were excluded from the present report. Demographic characteristics of the three subgroups are provided in Supplementary Table 1. Given the data collection times of W1 and W2, we assume that women pregnant in W1 were within 2 years of delivery in W2. Pregnancy status was based on self-report. The average gestational age (in weeks) among women pregnant in W1 and W2 was 20.7 (95% CI = 19.5% to 21.9%) and 20.7 (95% CI = 19.2% to 22.2%), respectively.

Measures

Types of Tobacco Products

The tobacco products examined included cigarettes, e-cigarettes, traditional cigars, filtered cigars, cigarillos, pipe tobacco, hookah, snus, smokeless tobacco (ie, moist snuff, dip, spit, or chewing tobacco), and dissolvable tobacco.

Categories of Tobacco Use

For all products, respondents were identified as current users or nonusers, where current users included respondents who met criteria for inclusion in either of the two PATH pre-defined categories of current established or current experimental users. Thus, for conventional cigarettes, current smokers were respondents who (a) reported smoking ≥100 lifetime cigarettes and smoking every day or some days (current established smokers), or (b) did not report smoking

≥100 lifetime cigarettes but were smoking every day or some days (current experimental smokers). For all other products, current users were defined as respondents who (a) reported having ever used the product fairly regularly and using some days or every day now (current established users), or (b) reported using the product before but not fairly regularly and using some days or every day now (current experimental users). Nonusers were those who did not meet the above criteria for using cigarettes or other tobacco products.

Respondents currently using any tobacco product were also categorized as single, dual, or poly users. Single product users were respondents currently using tobacco cigarettes alone, or another product alone who were nonusers across all other products examined. Dual product users were respondents currently using any two tobacco products who were nonusers of all other products. Poly users were those currently using ≥3 products.

Statistical Methods

We conducted each of the analyses described subsequently separately among the three subgroups of interest. To address our primary aim of identifying the most prevalent patterns of single and multiple tobacco product use among a US national sample of reproductive-aged women, we identified the five most common patterns of tobacco use in W1. Specifically, we report the overall prevalence of any tobacco use in W1 followed by the proportion of tobacco users engaging in each of the top five most prevalent patterns of use.

To address our secondary aim of characterizing the longitudinal trajectories of women engaged in specific patterns of tobacco use, we examined the proportion of women using each specific product or product combination in W1 who were using that same product(s), different product(s), or no tobacco products in W2. When describing trajectories of women engaged in specific patterns of tobacco use, we emphasize (a) the stability of the pattern (eg, proportion of W1 exclusive cigarette smokers who continued smoking cigarettes alone in W2), and (b) the most common transitions observed among respondents engaged in the pattern under study (eg, the most common trajectory among W1 hookah users was quitting tobacco use entirely in W2). Due to the small sample sizes among women who experienced a pregnancy in either W1 or W2, we limited this assessment to the top three most prevalent patterns of tobacco use among women not pregnant/pregnant, and to the top two most prevalent patterns of tobacco use among women pregnant/not pregnant.

As it was not feasible to examine the trajectory of women using all possible products and/or product combinations in W1, we supplemented the analyses above by conducting a comparable assessment using more general patterns of tobacco use (ie, nonuse, single product use, dual use, and poly use without specifying the products involved). More specifically, we examined (a) prevalence of each of these general patterns of tobacco use in W1, (b) the most common tobacco products and/or product combinations comprising each general pattern (eg, percentage of single product users who smoke cigarettes alone, e-cigarettes alone), and (c) the proportion of women engaged in each of these general patterns of tobacco use in W1 who were engaging in that same pattern, a different pattern, or were nonusers in W2. Due to small sample sizes the dual and poly use categories were collapsed into a single category of multiple tobacco product use (≥2 products) among the two subgroups that included pregnant women.

Frequencies and percentages were generated across all respondents and were weighted to account for the complex sampling scheme.

Variance estimation was conducted as a variant of balanced repeated replication (Fay's method),[24,25] using a predetermined value ε set to 0.3, recommended as the preferred procedure for the PATH Study.

Results

Tobacco Use Among Women Not Pregnant in Either Wave

Prevalence and Trajectories of Specific Patterns of Tobacco Use
Among women not pregnant/not pregnant, overall prevalence of any tobacco use in W1 was 27.0%, with the five most prevalent patterns of use being cigarettes alone (47.0%, 95% CI = 45.1% to 48.8%), cigarettes plus e-cigarettes (11.3%, 95% CI = 10.1% to 12.5%), hookah alone (10.1%, 95% CI = 9.0% to 11.3%), cigarettes plus hookah (4.8%, 95% CI = 4.0% to 5.7%), and e-cigarettes alone (3.4%, 95% CI = 2.7% to 4.1%).

The trajectories of women engaged in each of the above patterns of tobacco use across waves are displayed in Table 1 (top). Starting with those patterns of use involving one product, using cigarettes alone was the most stable pattern of tobacco use, with a majority (71.4%) of exclusive cigarette smokers in W1 remaining exclusive cigarette smokers in W2. Using e-cigarettes alone was also relatively stable, with 52.6% of exclusive e-cigarette users in W1 continuing to use e-cigarettes alone in W2, and the remaining women primarily switching to using cigarettes alone (12.4%) or some pattern of multiple product use involving cigarettes (17.7%). Using hookah alone was the least stable pattern of single product use, with only 35.2% of women using hookah alone in W1 continuing to do so in W2, and the most common trajectory for exclusive hookah users being to quit using tobacco entirely in W2 (48.5%). A relatively small but notable subset of exclusive hookah users (16.7%) in W1 transitioned to using hookah in combination with cigarettes or e-cigarettes or using another tobacco product combination in W2. Among dual users of cigarettes plus e-cigarettes, only 36.4% of women using this combination in W1 continued to do so in W2, with the most common trajectory for these women being to transition to using cigarettes alone (43.1%). Similarly, among dual users of cigarettes plus hookah, only 19.1% of women using this combination in W1 continued to do so in W2, with the most common trajectory again being to transition to using cigarettes alone (39.4%).

Prevalence and Trajectories of General Patterns of Tobacco Use
Overall prevalence of nonuse, single product use, dual use, and poly use in W1 were 73.0%, 17.2%, 6.6%, and 3.2%, respectively. The most common patterns of single product use were exclusive use of cigarettes (73.9% of single product users, 95% CI = 71.7% to 76.0%) or hookah (16.0% of single product users, 95% CI = 14.1% to 17.8%). The most common patterns of dual product use were using cigarettes plus e-cigarettes (46.2% of dual product users, 95% CI = 42.4% to 49.9%) and cigarettes plus hookah (19.7% of dual product users, 95% CI = 16.6% to 22.8%). The most common pattern of poly use was using cigarettes, e-cigarettes, cigarillos, and hookah (15.9% of poly-users, 95% CI = 10.2% to 21.6).

The trajectories of women engaged in each of the above general patterns of tobacco use are also shown in Table 1 (bottom). These data reveal a graded relationship whereby the proportion of women engaging in the same pattern of use across both waves decreased as the number of products involved increased. More specifically, 95.0%

Table 1. Tobacco Use Trajectories Among Women Not Pregnant in either Wave (*n* = 7480, weighted % = 92.8, 95% CI = 92.0% to 93.6%) Based on Specific Product(s) Used in W1 (Top), as well as General Pattern of Tobacco Use in W1 (Bottom)—Population Assessment of Tobacco and Health (PATH) Study, United States, 2013–2015

	Transitions between specific products and/or combinations across waves			
		Wave 2 product use		
Wave 1 product use	Product or combination	Weighted %	95% CI	Weighted *N*
Cigarette	Cigarette	71.4	68.9% to 73.9%	4 518 880
	Cigarette, e-cigarette	10.9	8.9% to 12.8%	687 485
(12.9%, 95% CI = 12.1% to 13.8%)	No tobacco products	9.0	7.3% to 10.7%	571 291
	E-cigarette	1.7	0.9% to 2.4%	105 432
	Cigarette, hookah	1.4	0.9% to 2.0%	89 581
	Other tobacco product/combination	5.6	4.6% to 6.6%	35 520
Cigarette, e-cigarette	Cigarette	43.1	37.5% to 48.7%	683 208
	Cigarette, e-cigarette	35.2	29.4% to 41.0%	557 805
(3.1%, 95% CI = 2.8% to 3.5%)	No tobacco products	6.9	4.0% to 9.7%	108 837
	E-cigarette	4.7	1.7% to 7.7%	74 760
	Cigarette, hookah	1.1	0.0% to 2.2%	17 602
	Other tobacco product/combination	9.1	6.5% to 11.6%	143 673
Hookah	No tobacco products	48.5	42.7% to 54.2%	596 917
	Hookah	35.2	29.1% to 41.3%	433 726
(2.8%, 95% CI = 2.3% to 3.2%)	Cigarette, hookah	4.2	1.9% to 6.4%	51 310
	Cigarette	2.8	1.0% to 4.5%	34 132
	E-cigarette, hookah	2.7	1.1% to 4.2%	32 744
	Other tobacco product/combination	6.7	4.1% to 9.4%	83 157
Cigarette, hookah	Cigarette	39.4	30.7% to 48.0%	258 085
	Cigarette, hookah	19.1	11.2% to 27.1%	125 525
(1.3%, 95% CI = 1.1% to 1.6%)	No tobacco products	15.3	8.9% to 21.7%	100 194
	Hookah	7.1	1.9% to 12.2%	46 271
	Cigarette, e-cigarette, hookah	7.0	3.2% to 10.8%	45 623
	Other tobacco product/combination	12.2	7.1% to 17.3%	80 145
E-cigarette	E-cigarette	52.6	43.5% to 61.8%	223 598
	Cigarette, e-cigarette	15.1	7.7% to 22.5%	64 176
(0.9%, 95% CI = 0.7% to 1.1%)	No tobacco products	13.4	7.0% to 19.7%	56 773
	Cigarette	12.4	6.0% to 18.7%	52 491
	Cigarette, e-cigarette, cigarillo	2.2	0.0% to 4.8%	9154
	Other tobacco product/combination	4.4	0.6% to 8.1%	18,534
Other product/combination (6.4%, 95% CI = 6.0% to 6.9%)				3 955 295

	Transitions between general patterns across waves			
		Wave 2 pattern		
Wave 1 pattern	General tobacco use pattern	Weighted %	95% CI	Weighted *N*
No use	No use[a]	95.0	94.3% to 95.7%	34 748 301
	Single product use[b]	4.0	3.3% to 4.7%	1 453 737
(73.0%, 95% CI = 71.7% to 74.3%)	Dual use[c]	0.8	0.5% to 1.1%	292 894
	Poly use[d]	0.2	0.1% to 0.3%	81 499
Single product use	No use	21.0	19.2% to 22.7%	1 810 908
	Single product use	62.9	60.4% to 65.4%	5 435 772
(17.2%, 95% CI = 16.2% to 18.3%)	Dual use	13.6	12.0% to 15.3%	1 178 280
	Poly use	2.5	1.9% to 3.1%	217 994
Dual use	No use	12.8	10.2% to 15.3%	420 636
	Single product use	44.2	40.3% to 48.2%	1 454 054
(6.6%, 95% CI = 6.1% to 7.0%)	Dual use	34.3	30.5% to 38.0%	1 126 321
	Poly use	8.7	6.9% to 10.5%	286 118
Poly use	No use	10.3	7.6% to 13.0%	163 952
	Single product use	31.5	27.3% to 35.7%	502 183
(3.2%, 95% CI = 2.9% to 3.5%)	Dual use	27.0	22.8% to 31.1%	429 620
	Poly use	31.2	26.8% to 35.6%	497 293

Overall prevalence of specific tobacco products and/or tobacco product combinations and general patterns is provided in W1 (column 1).

[a]Did not meet criteria for current use of tobacco cigarettes or any other noncigarette tobacco product. [b]Single product users met criteria for being a current tobacco cigarette smoker or current user of another product, and were nonusers across all other products examined.

[c]Dual users met criteria for being current users of tobacco cigarettes plus one additional noncigarette tobacco product, or current users of two noncigarette tobacco products, and were nonusers across all other products examined.

[d]Poly users met criteria for current use of three or more tobacco products, either including or excluding tobacco cigarettes.

of women using zero products in W1 continued, to do so in W2 while 62.9%, 34.3%, and 31.2% of single, dual, and poly product users continued in the same use patterns in W1 and W2, respectively. When women transitioned to a new pattern from W1 to W2, they generally transitioned to patterns involving none or fewer products rather than more.

Changes in Tobacco Product Use Upon Transitioning Into Pregnancy

Prevalence and Trajectories of Specific Patterns of Tobacco Use

Among the subgroup of women not pregnant/pregnant, overall prevalence of any tobacco use before pregnancy (W1) was 27.6%, with the most common patterns of use being cigarettes alone (45.3%, 95% CI = 35.8% to 54.8%), cigarettes plus e-cigarettes (11.5%, 95% CI = 4.5% to 18.5%), cigarettes plus hookah (6.8%, 95% CI = 2.8% to 10.8%), hookah alone (6.6%, 95% CI = 2.2% to

10.9%), and poly use of cigarettes, cigarillos, and hookah (4.2%, 95% CI = 0.7% to 7.8%).

The trajectories of women engaged in each of the top three most common patterns of tobacco use are shown in Table 2 (top). Among women using cigarettes alone in W1, the majority (54.1%) remained exclusive cigarette smokers upon entering pregnancy in W2. The remainder generally quit using tobacco (40.6%), with a small proportion of women (5.3%) switching to a new tobacco product or combination during pregnancy. Among women using cigarettes plus e-cigarettes in W1, the majority (52.5%) dropped the e-cigarettes and smoked cigarettes alone during pregnancy in W2, 26.6% quit using tobacco products, and 20.9% switched to a new product or combination in W2. In contrast to cigarette smokers and dual cigarette plus e-cigarette users, the most common trajectory among women using cigarettes plus hookah before pregnancy in W1 was to quit using both products in W2 (76.8%), with the remainder dropping the hookah thereby returning to exclusive cigarette smoking

Table 2. Tobacco Use Trajectories Among Women Not Pregnant in W1 and Pregnant in W2 (*n* = 332, weighted % = 3.6, 95% CI = 3.1% to 4.1%) Based on Specific Product(s) Used in W1 (Top), as well as General Pattern of Tobacco Use in W1—Population Assessment of Tobacco and Health (PATH) Study, United States, 2013–2015

	Transitions between specific products and/or combinations across waves			
	Wave 2 product use			
Wave 1 product use	Product or combination	Weighted %	95% CI	Weighted *N*
Cigarette	Cigarette	54.1	36.9% to 71.2%	104,040
(12.6%, 95% CI = 8.7% to 16.5%)	No tobacco products	40.6	22.6% to 58.6%	78,145
	Other tobacco product/combination	5.3	0.0% to 10.6%	10,224
Cigarette, e-cigarette	Cigarette	52.5	21.2% to 83.8%	32,589
(3.2%, 95% CI = 1.2% to 5.2%)	No tobacco products	26.6	3.9% to 49.4%	15,547
	Other tobacco product/combination	20.9	0.0% to 46.7%	143,673
Cigarette, hookah	No tobacco products	76.8	51.1% to 100.0%	24,666
(1.9%, 95% CI = 0.7% to 3.1%)	Cigarette	11.6	0.0% to 39.2%	5,192
	E-cigarette	7.4	0.0% to 21.7%	2,238
Other product/combination (7.1%, 95% CI = 4.5% to 9.7%)				137,808

	Transitions between general patterns across waves			
	Wave 2 pattern			
Wave 1 pattern	General tobacco use pattern	Weighted %	95% CI	Weighted *N*
No use	No use[a]	98.8	97.1% to 100.0%	1 400 341
(72.4%, 95% CI = 66.6% to 78.2%)	Single product use[b]	0.9	0.0% to 2.5%	12 235
	Multiple product use[c]	0.3	0.0% to 0.9%	3859
Single product use	No use	61.0	46.9% to 75.1%	182 875
(15.2%, 95% CI = 11.0% to 19.4%)	Single product use	35.3	22.0% to 48.7%	104 040
	Multiple product use	3.7	3.1% to 18.0%	10 224
Multiple product use	No use	55.7	42.2% to 69.2%	133 669
(12.4%, 95% CI = 7.5% to 17.2%)	Single product use	33.7	19.5% to 47.9%	83 437
	Multiple product use	10.6	3.1% to 18.0%	24 968

Overall prevalence of specific tobacco products and/or tobacco product combinations and general patterns is provided in W1 (column 1).
[a]Did not meet criteria for current use of tobacco cigarettes or any other noncigarette tobacco product.
[b]Single product users met criteria for being a current tobacco cigarette smoker or current user of another product, and were nonusers across all other products examined.
[c]Multiple product users included both dual users (respondents who met criteria for being current users of tobacco cigarettes plus one additional noncigarette tobacco product, or current users of two noncigarette tobacco products, and were nonusers across all other products examined) and poly users (respondents using ≥3 tobacco products).

(11.6%), or switching to exclusive e-cigarette use (7.4%). Although not explicitly shown in Table 2, the percentage of women using one or more tobacco products in W1 who quit using tobacco upon entering pregnancy in W2 was 58.7% (95% CI = 49.2% to 68.2%).

Prevalence and Trajectories of General Patterns of Tobacco Use

Prevalence of nonuse, single product use, dual, and poly use before becoming pregnant was 72.4%, 15.2%, 8.4%, and 4.0%, respectively. The most common patterns of single product use were exclusive use of cigarettes (82.2% of single product users, 95% CI = 72.6% to 91.8%) or hookah (11.9% of single product users, 95% CI = 4.1% to 19.7%). The most common patterns of multiple product use (≥2 products) were using cigarettes plus e-cigarettes (25.7%, 95% CI = 11.7% to 69.6%) and cigarettes plus hookah (15.2%, 95% CI = 6.7% to 23.6%).

Transitions between general patterns of tobacco use upon entering pregnancy are displayed in Table 2 (bottom). Among this subgroup, a sharply graded relationship is observed whereby the proportion of women engaging in the same pattern of use across both waves decreases dramatically as the number of products involved in the pattern increases. More specifically, 98.8% of nonusers in W1 remained nonusers upon entering pregnancy in W2. Among women using a single tobacco product in W1, 35.3% continued to do so in W2, whereas the majority (61.0%) quit using tobacco products entirely. Among women engaged in multiple product use before pregnancy in W1, only 10.6% continued using ≥2 tobacco products upon becoming pregnant in W2, with the majority (55.7%) quitting tobacco use entirely and the remaining 33.7% becoming single product users in W2.

Changes in Tobacco Product Use Upon Transitioning from Pregnant to Not Pregnant

Prevalence and Trajectories of Specific Patterns of Tobacco Use

Among women pregnant/not pregnant, overall prevalence of any tobacco use during pregnancy in W1 was 15.7%, with the most prevalent tobacco products and/or combinations being cigarettes alone (52.2%, 95% CI = 40.9% to 63.6%), cigarettes plus e-cigarettes (15.8%, 95% CI = 8.7% to 23.0%), e-cigarettes alone (6.0%, 95% CI = 0.5% to 11.5%), poly use of cigarettes, e-cigarettes, cigarillos, and hookah (3.4%, 95% CI = 0.0% to 7.9%), and dual use of cigarettes plus hookah (3.4%, 95% CI = 0.0% to 7.0%).

The trajectories of women engaged in each of the top two most common patterns of tobacco use are shown in Table 3 (top). Among women who smoked cigarettes alone during their pregnancy in W1, 73.9% maintained this pattern of exclusive cigarette smoking when they were no longer pregnant in W2, while 13.1% added e-cigarettes to their product use thereby becoming dual users. Less than 2.0% of the women who smoked cigarettes alone during pregnancy went on to quit using tobacco entirely in W2. Among women engaged in dual use of cigarettes plus e-cigarettes during pregnancy in W1, the majority (61.1%) dropped the e-cigarettes thereby using cigarettes alone when no longer pregnant in W2, 23.9% transitioned to using e-cigarettes alone, and 15.1% switched to some other pattern of tobacco use. None of the women who used cigarettes plus e-cigarettes during pregnancy transitioned to nonuse following pregnancy.

Prevalence and Trajectories of General Patterns of Tobacco Use

Prevalence of nonuse, single-, dual-, and polytobacco product use during pregnancy in W1 were 84.3%, 9.7%, 3.7%, and 2.3%, respectively. The most common patterns of single product use during pregnancy in W1 were exclusive use of cigarettes (84.6% of single-product users, 95% CI = 73.7% to 95.6%) and e-cigarettes (9.7% of single product users, 95% CI = 0.6% to 18.7%). The most common patterns of multiple product use (≥2 products) were cigarettes plus e-cigarettes (41.3%, 95 CI 24.9, 57.8) and cigarettes plus hookah (8.9%, 95% CI = 0.0% to 18.4%).

Transitions between general patterns of tobacco use across waves are shown in Table 3 (bottom). As with the subgroups above, patterns of tobacco use involving more products were less stable across waves, with 88.8%, 64.1%, and 34.2% of W1 nonusers, single product users, and multiple product users continuing in these same patterns in W2, respectively. Unlike the subgroups above, however, when women in this subgroup transitioned to a new pattern of tobacco use between W1 and W2, the new pattern more often included an increase rather than a decrease in the number of products used.

Discussion

This study provides the first longitudinal examination of patterns of tobacco use in a US national sample of reproductive-aged women. There are six points on which we wish to comment. First, the results on patterns of use are consistent with patterns reported previously for the general adult population in W1 of PATH.[22] For example, the 17.2% prevalence for single product use and 9.8% for dual/poly use combined that were observed in the present study among women not pregnant/not pregnant is comparable to the 16.4% and 10.0% estimates for single and multiple tobacco product use (≥2 products), respectively, reported among the general population.[22] Both patterns of use were lower by approximately 40% among women pregnant in W1 (9.7%, 6.0%). The finding that exclusive use of conventional cigarettes is the most prevalent pattern of tobacco use among the present sample of women and that most patterns of multiple product use include cigarettes is also consistent with estimates for the general population of adults who completed W1 of PATH where 63.7% of single product use and 76.2% of multiple product use involved cigarettes.[22] Regarding women who transitioned into pregnancy across waves, the subgroup of women not pregnant/pregnant provided what to our knowledge is the first estimate, using a nationally representative, longitudinal study design, of the proportion of women who discontinue use of any tobacco product upon learning of a pregnancy (58.7%). This estimate is consistent with those reported for conventional cigarette smoking in a recent study using PRAMS, where 54.3% of women reported quitting upon learning of pregnancy.[14]

Second, our examination of the longitudinal trajectories of women engaged in particular patterns of tobacco use indicated that dual and polytobacco use are considerably less stable than exclusive use of a single product, with those using multiple products in W1 more often reducing or quitting tobacco in W2 rather than adopting new patterns involving more products. It is worth considering these findings in light of recent studies that raise concerns about increases in multiple product use among young adults,[26,27] as the present results suggest that such patterns are transient regardless of pregnancy status and followed more commonly by reductions rather than escalations in tobacco use. However, it is worth noting that the present study examined transitions over only a 1-year period. Trend analyses of tobacco use patterns across several time points will be necessary to identify the longer-term end points for multiple product

Table 3. Tobacco Use Trajectories Among Women Pregnant in W1 and Not Pregnant in W2 (*n* = 325, weighted % = 3.6, 95% CI = 3.0% to 4.1%) Based on Specific Product(s) Used in W1 (Top), as well as General Pattern of Tobacco Use in W1 (Bottom)—Population Assessment of Tobacco and Health (PATH) Study, United States, 2013–2015

	Transitions between specific products and/or combinations across waves			
		Wave 2 product use		
Wave 1 product use	Product or combination	Weighted %	95% CI	Weighted *N*
Cigarette	Cigarette	73.9	60.7% to 87.9%	4 117 003
(8.4%, 95% CI = 5.9% to 10.9%)	Cigarette, e-cigarette	13.1	1.5% to 24.7%	687 485
	No tobacco products	1.7	0.0% to 5.0%	493 136
	Other tobacco product/combination	11.3	2.5% to 20.1%	320 240
Cigarette, e-cigarette	Cigarette	61.1	31.5% to 90.6%	650 619
(2.5%, 95% CI = 5.9% to 10.9%)	E-cigarette	23.9	0.0% to 50.7%	554 193
	No tobacco products	0.0	—	—
	Other tobacco product/combination	15.1	0.0% to 35.7%	143 673
Other product/combination (3.1%, 95% CI = 1.5% to 4.6%)				58 185

Transitions between general patterns across waves

		Wave 2 pattern		
Wave 1 pattern	General tobacco use pattern	Weighted %	95% CI	Weighted *N*
No use	No use[a]	88.8	84.9% to 92.8%	1 450 778
(84.3%, 95% CI = 80.7% to 87.9%)	Single product use[b]	8.4	5.1% to 11.6%	136 656
	Multiple product use[c]	2.8	0.9% to 4.7%	45 643
Single product use	No use	9.8	1.2% to 18.3%	17 346
9.7% (95% CI =7.2% to 12.2%)	Single product use	64.1	50.8% to 77.5%	120 296
	Multiple product use	26.1	14.6% to 37.5%	48 884
Multiple product use	No use	2.7	0.0% to 8.0%	3101
6.0% (95% CI = 3.1% to 8.9%)	Single product use	63.1	45.9% to 80.3%	73 414
	Multiple product use	34.2	17.1% to 51.3%	39 819

Overall prevalence of specific tobacco products and/or tobacco product combinations and general patterns is provided in W1 (column 1).

[a]Did not meet criteria for current use of tobacco cigarettes or any other noncigarette tobacco product.

[b]Single product users met criteria for being a current tobacco cigarette smoker or current user of another product, and were nonusers across all other products examined.

[c]Multiple product users included both dual users (respondents who met criteria for being current users of tobacco cigarettes plus one additional noncigarette tobacco product, or current users of two noncigarette tobacco products, and were nonusers across all other products examined) and poly users (respondents using ≥3 tobacco products).

users and thereby clarify what level of concern about multiple product use is warranted. In most cases, transitions from dual to single product use in the present study involved dropping the noncigarette tobacco product and smoking cigarettes exclusively in W2. Future research using more sophisticated analyses such as Markov modeling[28] would be helpful in quantifying probabilities of transitioning to specific patterns of use over time and in relation to changes in reproductive status. Considering recent increases in dual use of tobacco and marijuana among reproductive-aged women,[29] future research should also examine prevalence and trajectories of use combinations involving marijuana, particularly as states are increasingly legalizing this substance for recreational use.

Third, although a few small studies indicate that some women use e-cigarettes in efforts to quit smoking tobacco cigarettes,[11] including pregnant women,[30,31] whether e-cigarettes served this purpose among the present sample is unclear. Among women not pregnant/not pregnant, a minority (<15%) of women using either cigarettes alone or cigarettes plus e-cigarettes together in W1 switched to exclusive e-cigarette use or quit using tobacco in W2. Conversely, nearly one-third (29.7%) of women not pregnant/not pregnant who were using e-cigarettes alone in W1 switched to exclusive cigarette smoking or some combination of multiple product use including cigarettes in W2. The utility of e-cigarettes in facilitating cessation of cigarette smoking among those transitioning to or from pregnancy is also unclear. More specifically, the most common trajectory among women using cigarettes alone or cigarettes plus e-cigarettes before transitioning into or out of pregnancy in the present study was to using cigarettes alone in W2. That said, slightly over a quarter (26.6%) of women engaged in dual cigarette plus e-cigarette use before pregnancy reported no longer using either product upon entering pregnancy, and a small proportion of women (7.4%) engaged in dual cigarette plus hookah use before pregnancy switched to using e-cigarettes alone during pregnancy. Considered together, these results suggest that regardless of pregnancy status, e-cigarettes may serve as a harm reduction or tobacco cessation tool for only a minority of women. However, these findings should be interpreted cautiously as these data cannot definitively address this question and e-cigarettes as a smoking cessation aid during pregnancy has not been evaluated.[32] Clearly, further research is needed to better understand whether and the conditions

under which e-cigarettes may facilitate cessation of combusted tobacco use among women of reproductive age generally, and those transitioning to or from pregnancy more specifically.

Fourth, the results from women not pregnant/not pregnant provide new information on trajectories of hookah use across time among women of reproductive age. Hookah use has been increasing internationally including among college students and other youth and young adults in the United States, partly due to inaccurate perceptions that hookah smoking is less harmful than cigarette smoking or other forms of combusted tobacco use.[33,34] Among those reporting exclusive use of hookah in W1 in the present study, a striking 48.5% report not using any tobacco products in W2, which is encouraging in light of the growing use of this product. Indeed, exclusive users of hookah in W1 were the only type of user in the present study where no tobacco product use in W2 was the most common transition. These findings indicating the relative instability of hookah use across waves are generally consistent with those from a longitudinal study conducted among college students where only 13.0% of current cigarette smokers and 2.0% of noncigarette smokers reported using hookah in both waves of a survey conducted twice over a 14-month period.[35] However, it is also the case that approximately one-third (35.2%) of exclusive hookah users in W1 of the present study continued with the practice of exclusive hookah use in W2, documenting that this practice is stable over time in a sizeable proportion of women. That pattern is concerning in light of evidence that hookah use can indeed result in high levels of toxin exposure.[36] Also concerning is that 16.4% of exclusive hookah users in W1 transitioned to conventional cigarettes alone (2.8%), e-cigarettes plus hookah (2.7%), or another tobacco product combination in W2 suggesting that hookah use may serve as an entry into use of other tobacco products for a subset of young women.

Fifth, the present study results have important tobacco control and regulatory policy implications. Considering that cigarettes were the most common product used regardless of pregnancy status, with most patterns of multiple product use including cigarettes, more intensive and targeted tobacco control interventions to reduce cigarette use among women of reproductive age should be considered. One context where communication surrounding tobacco use could be improved is between reproductive-aged women and their health care providers. The extent to which providers screen for tobacco use appears to be variable as even among pregnant women only ~6.0% of providers arrange for follow-up visits addressing smoking cessation with women who report current cigarette smoking.[37] Efforts to increase provider adherence to current Clinical Practice Guidelines[38] with respect to screening and following up with women who report tobacco use would improve, at a minimum, communication about risks of use between women and their providers and, at best, cessation rates. Because e-cigarettes were also quite prevalent among the present sample including among pregnant women, it will also be important to increase provider awareness and promote consistent health messaging about e-cigarette use. In a recent study, 40% of obstetricians–gynecologists indicated that they never screen pregnant women for noncombustible tobacco use,[39] and women report receiving highly inconsistent messaging regarding the safety of using e-cigarettes during pregnancy.[40] Future research examining effects of e-cigarettes on maternal and infant health is imperative to clarify the messages that practitioners should convey to pregnant women who report using e-cigarettes. The same applies to hookah use. Taking steps to assure that health care providers are informed about the

increasing prevalence and documented toxicity of hookah use, and encouraging them to explicitly inquire about hookah use when discussing tobacco use with reproductive-aged women, is warranted.

In terms of regulatory implications, several merit mention. The Family Smoking Prevention and Tobacco Control Act of 2009 gives the FDA regulatory authority to lower the maximal nicotine content of cigarettes to very low levels. Very low nicotine content (VLNC) cigarettes reduce nicotine exposure and dependence with minimal compensatory smoking.[41–43] Thus women of reproductive age using VLNCs may have lower risk of dependence and improved chances of quitting smoking should they become pregnant. Recent research with economically disadvantaged women of reproductive age and other populations especially vulnerable to tobacco addiction indicating that VLNCs have a lower potential to produce addiction compared to cigarettes containing nicotine at current commercial levels provides support for this possibility.[44,45] Regulatory policies that promote switching from combusted to noncombusted sources of nicotine are likely to reduce health harms among a majority of vulnerable populations including nonpregnant women of reproductive age;[46] however, it is unclear whether this strategy would reduce harm among pregnant women given the fetal toxicity of nicotine. Finally, broad regulatory actions for the general population that restrict marketing of all tobacco products to vulnerable groups and increase health communication about the effects of tobacco products may decrease use among reproductive-aged women.

Last, the present study has several limitations that merit mention. First, although the relatively low number of pregnant women in W1 and W2 of the PATH Study reflects the prevalence of pregnancy among US women (~4.0%), the small sample may have reduced the accuracy of some prevalence estimates and produced variation across the two subgroups of women who experienced a pregnancy. Indeed some of the confidence intervals surrounding prevalence estimates among these subgroups were quite wide. Alternatively, variation across these subgroups may reflect exposure to different messaging about alternative tobacco products or a cohort effect. Small cell sizes also prohibited an assessment of whether certain patterns of tobacco use differ among pregnant women who vary in terms of demographic characteristics (eg, age, race, socioeconomic status). Further research is needed to examine differences in tobacco use among higher-risk populations, who are more likely to smoke during pregnancy. Second, tobacco use was based on self-report, which is associated with underreporting particularly during pregnancy. Third, women were queried about their tobacco use once per wave at the time of the interview, thus tobacco use at this time may not reflect use throughout the entire pregnancy. Fourth, we could not obtain information about the temporal timing of changes in patterns of tobacco use, that is, whether women who transitioned to new patterns of use from W1 to W2 did so immediately upon learning of pregnancy or giving birth, or more distally. Finally, we did not examine frequency of use in this report (eg, cigarettes per day), thus we cannot draw conclusions regarding how intensity of cigarette smoking or use of other products factors into the different use patterns observed.

Notwithstanding these limitations, this study contributes new knowledge about the various ways that reproductive-aged women use tobacco products over time and when punctuated by pregnancy. More specifically, the present results illustrate the transient nature of multiple tobacco product use among reproductive-aged women over a 1-year period, with multiple product users generally being more likely to decrease rather than increase the number of products used over time. The results also indicate that emerging tobacco products

(eg, e-cigarettes, hookah) are quite prevalent including during pregnancy and often used in combination with conventional cigarettes, with the emerging products more often discarded over time relative to cigarettes. That pattern notwithstanding, the observation that some dual cigarette plus e-cigarette users quit using tobacco entirely upon entering pregnancy demonstrates a need for research that systematically examines the utility of e-cigarettes as a smoking cessation aid for pregnant women. Considered together, the new knowledge generated by this study has potential to inform intervention, educational, and policy efforts to reduce tobacco use and thereby improve health in this vulnerable population and their offspring.

Supplementary Material

Supplementary data are available at *Nicotine & Tobacco Research* online.

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Declaration of Interest

None declared.

Supplement Sponsorship

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