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## Co-occurrence of tobacco product use, substance use, and mental health problems among youth: Findings from wave 1 (2013–2014) of the population assessment of tobacco and health (PATH) study



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### HIGHLIGHTS

- Youth tobacco users were more likely to use alcohol or drugs compared to non-users.
- Youth tobacco users were more likely to have substance use and mental health problems.
- In particular, poly-tobacco use was strongly associated with substance use problems.
- Female tobacco users were more likely to have substance use and internalizing problems.
- Comprehensive interventions and treatments can effectively address youth comorbidities.

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### ABSTRACT

**Introduction:** Cigarette use is associated with substance use and mental health problems among youth, but associations are unknown for non-cigarette tobacco product use, as well as the increasingly common poly-tobacco use.

**Methods:** The current study examined co-occurrence of substance use and mental health problems across tobacco products among 13,617 youth aged 12–17 years from Wave 1 (2013–2014) of the nationally representative Population Assessment of Tobacco and Health (PATH) Study. Participants self-reported ever cigarette, e-cigarette, smokeless tobacco, traditional cigar, cigarillo, filtered cigar, hookah, and other tobacco product use; alcohol, marijuana, and other drugs; and lifetime substance use, internalizing and externalizing problems.

**Results:** In multivariable regression analyses, use of each tobacco product was associated with substance use, particularly cigarillos and marijuana (AOR = 18.9, 95% CI: 15.3–23.4). Cigarette (AOR = 14.7, 95% CI: 11.8–18.2) and cigarillo (AOR = 8.1, 95% CI: 6.3–10.3) use were strongly associated with substance use problems and tobacco users were more likely to report internalizing (AOR = 1.6, 95% CI: 1.4–1.8) and externalizing (AOR = 1.4, 95% CI: 1.3–1.6) problems. Female tobacco users were more likely to have internalizing problems than male tobacco users. Poly-tobacco users were more likely than exclusive users to use substances (AOR = 3.4, 95% CI: 2.7–4.3) and have mental health (AOR = 1.2, 95% CI: 1.0–1.5) and substance use (AOR = 4.7, 95% CI: 3.4–6.6) problems.

**Conclusions:** Regardless of the tobacco product used, findings reveal high co-occurrence of substance use and

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mental health problems among youth tobacco users, especially poly-tobacco users. These findings suggest the need to address comorbidities among high risk youth in prevention and treatment settings.

## 1. Introduction

Although cigarette smoking has continually declined in the United States, cigarette use remains common among youth (Arrazola et al., 2015). Furthermore, national surveys show that use of non-cigarette products such as e-cigarettes, hookah, little cigars, and smokeless tobacco has become increasingly common (Arrazola et al., 2015; Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2017; Kasza et al., 2017; Y. O. Lee, Hebert, Nonnemaker, & Kim, 2015). Previous research has found consistent associations with certain tobacco products (especially cigarettes), alcohol or drugs, and mental health problems among U.S. youth. No study to date has examined these associations across tobacco products, addictive substances, and internalizing and externalizing mental health problems in a nationally representative sample. Moreover, approximately four in ten current tobacco users report using two or more products (Kasza et al., 2017), but scant research has examined the role of poly-tobacco use in these associations.

While available research suggests that the strong association between cigarette use and substance use may extend across specific substances (Richter, Pugh, Smith, & Ball, 2017), this has never been examined in a systematic and comprehensive manner (Kandel, Yamaguchi, & Chen, 1992). This literature is limited not only by a narrow focus on alcohol and marijuana, but few studies focus on emerging tobacco products, such as e-cigarettes, cigar types and hookah, that are commonly used by American youth (Kasza et al., 2017). Additionally, a 2012 review found high co-occurrence of tobacco (mostly cigarettes) and marijuana among youth and young adults in the majority of cross-sectional and longitudinal studies examined (Ramo, Liu, & Prochaska, 2012). Other recent studies show that hookah (water pipe) use is similarly associated with greater marijuana use among U.S. high school seniors and college students (Goodwin et al., 2014; Palamar, Zhou, Sherman, & Weitzman, 2014). Emerging research on e-cigarettes has documented an association between e-cigarette use and use of alcohol, marijuana, and other illicit substances (Demissie, Everett Jones, Clayton, & King, 2017; Westling, Rusby, Crowley, & Light, 2017), although much of this research compares e-cigarette use to cigarette use or dual use of both cigarettes and e-cigarettes (Dunbar et al., 2017; Kristjansson, Mann, & Smith, 2017; McCabe, West, Veliz, & Boyd, 2017).

Similarly, the assessment of the association between youth tobacco use and mental health problems is generally limited to cigarette smoking. Studies suggest a positive association between youth tobacco use and internalizing problems including depressive symptoms (Lechner, Janssen, Kahler, Audrain-McGovern, & Leventhal, 2017; Leventhal et al., 2016; Mistry, Babu, Mahapatra, & McCarthy, 2014; Tercyak & Audrain, 2002) and anxiety (Marmorstein et al., 2010; Marmorstein, White, Loeber, & Stouthamer-Loeber, 2010; Zehe, Colder, Read, Wiczorek, & Lengua, 2013). Youth cigarette smoking has also been associated with externalizing disorders involving disruptive behavior, including conduct disorder (Armstrong & Costello, 2002; Colder et al., 2013; Leventhal et al., 2016; National Center for Chronic Disease Prevention and Health Promotion (US) Office on and Smoking Health, 2012), oppositional defiant disorder, and attention-deficit/hyperactivity disorder (ADHD) (Brinkman, Epstein, Aunger, Tamm, & Froehlich, 2015; Elkins, McGue, & Iacono, 2007; Groenman et al., 2013; S. S. Lee, Humphreys, Flory, Liu, & Glass, 2011). Moreover, although two nationally representative studies found that youth poly-tobacco use was associated with alcohol, marijuana, and other drug disorders (Cavazos-Rehg, Krauss, Spitznagel, Grucza, & Bierut, 2014;

Richter, Pugh, Smith, & Ball, 2017), these did not focus on co-occurring mental health problems.

Examining these associations across the full range of tobacco products used by American adolescents, a high-risk population for the onset and exacerbation of tobacco use, substance use, and mental health problems (Office of the Surgeon General, 2016; Robinson & Riggs, 2016), is essential. Therefore, using Wave 1 data from the Population Assessment of Tobacco and Health (PATH) Study, the present study examined co-occurrence of substance use, substance use problems, and mental health (internalizing and externalizing) problems across 12 tobacco products. This study further examined these associations by poly-tobacco use.

## 2. Methods

### 2.1. Study design and participants

The PATH Study is a nationally representative longitudinal study of 45,971 U.S. adults (18 years and older) and youth (12–17 years) designed to examine tobacco use and health. This paper reports Wave 1 (September 2013–December 2014) data from 13,617 youth participants with complete data on variables for the specific associations examined. Participants were recruited via an address-based, area-probability sampling approach, using an in-person household screener to select youth from households that oversampled adult tobacco users, young adults, and African-American adults. Generally, up to two youth were sampled per household. The weighting procedures adjusted for oversampling and nonresponse, allowing estimates to be representative of the non-institutionalized, civilian U.S. population. The weighted response rate among sampled youth was 78.4%.

After obtaining consent from parents and emancipated youth and assent from youth, data were collected using Audio-Computer Assisted Self-Interviews administered in English or Spanish. Detailed methodological information about the study design and protocol is available elsewhere (Hyland et al., 2017) and at <http://www.icpsr.umich.edu/icpsrweb/NAHDAP/series/606>. The study was conducted by Westat and approved by Westat's Institutional Review Board.

### 2.2. Measures

#### 2.2.1. Tobacco use

Ever use of tobacco products was determined based on participants' responses to questions on lifetime use (dichotomized as no = 0, yes = 1) of the following: cigarettes, e-cigarettes, traditional cigars, cigarillos, filtered cigars, pipe, hookah, smokeless tobacco (i.e. loose snus, moist snuff, dip, spit, or chewing tobacco), snus pouches, kreteks, bidis, and dissolvable tobacco. A brief description and pictures of each product (except cigarettes) were shown to participants before being asked about the products. Additional questions were asked of cigar users to determine cigar type.

'Any tobacco use' was defined as ever using any tobacco product, 'any cigar use' was defined as ever using traditional cigars, cigarillos, or filtered cigars, and 'smokeless including snus' was defined as ever using smokeless tobacco or snus pouches. Among tobacco users, 'poly-use' of any tobacco was defined as ever use of any two or more of the following 8 tobacco product categories: cigarettes, e-cigarettes, any cigar, pipe, hookah, any type of smokeless tobacco (i.e., smokeless tobacco, snus pouches or dissolvable tobacco), kreteks, and bidis, versus exclusive use of any tobacco product, which was defined as ever use of only one of these 8 tobacco product categories. 'Poly-use' of cigarettes was defined

as ever use of cigarettes and ever use of at least one of the other 7 tobacco product categories, versus exclusive use of cigarettes, which was defined as ever use of only cigarettes. ‘Poly-use’ of e-cigarettes was defined as ever use of e-cigarettes and ever use of at least one of the other 7 tobacco product categories, versus exclusive use of e-cigarettes, which was defined as ever use of only e-cigarettes. For each poly-use variable, complete data were required to categorize participants as exclusive users, but were not required to categorize participants as poly-users.

### 2.2.2. Substance use

Self-reported ever use was defined and dichotomized separately (no = 0, yes = 1) as lifetime use of each of the following: alcohol, marijuana (including blunts), misuse of prescription drugs (i.e. Ritalin® or Adderall®; painkillers, sedatives, or tranquilizers), and other drugs (cocaine or crack, stimulants (i.e. methamphetamine or speed), heroin, inhalants, solvents, and hallucinogens).

In addition, ever use of alcohol or any drug was defined as the lifetime use of any of the above substances (dichotomized as no = 0, yes = 1). Substance use items in the PATH Study were adapted from the National Epidemiologic Survey on Alcohol and Related Conditions (National Institutes of Health (NIH); National Institute on Alcohol Abuse and Alcoholism (NIAAA), 2004–2005) and the National Health and Nutrition Examination Survey (Centers for Disease Control and Prevention (CDC); National Center for Health Statistics (NCHS), 2011–2012).

### 2.2.3. Substance use and mental health problems

Substance use and mental health problems were assessed via the Global Appraisal of Individual Needs - Short Screener (GAIN-SS), modified for the PATH Study (M. L. Dennis, Chan, & Funk, 2006). The GAIN-SS identifies individuals at risk for mental health or substance use disorders using a continuous measure of severity. Items for the GAIN-SS were derived from the full GAIN instrument, a validated, standardized biopsychosocial assessment for individuals entering treatment for substance use or mental health disorders (Garner, Belur, & Dennis, 2013) and recommended for use in epidemiological samples by the PhenX Toolkit (Hamilton et al., 2011). The PATH Study assessed severity

across three subscales: substance use problems, internalizing problems, and externalizing problems. Table 1 displays the items and reliability (Tavakol & Dennick, 2011) for each subscale.

The GAIN-SS measures problems across four time periods: past month, 2–12 months ago, over a year ago, and never. Given the relatively low proportions of youth substance use, the current study focused on lifetime measures to maximize stability of the estimates. The number of responses endorsed in the lifetime were summed for each subscale (complete data for subscale components were required). Summary scores ranged from 0 to 7 for substance use, 0–4 for internalizing, and 0–7 for externalizing problems. Based on the number of symptoms endorsed, participants were categorized into three severity levels: no/low (0–1 symptoms), moderate (2–3 symptoms), or high (4 for internalizing problems, or  $\geq 4$  symptoms for substance use and externalizing problems). These cut points were informed by previous studies showing concurrent and predictive validity in other samples (M. L. Dennis, et al., 2006; Garner, Belur, & Dennis, 2013). While individuals categorized as no/low severity are unlikely to have a diagnosis or need services, moderate severity indicates a possible diagnosis and need of services, and high severity indicates high likelihood of a disorder and need for services (M. Dennis, Feeney, Stevens, & Bedoya, 2006).

### 2.2.4. Covariates

Information was collected on socio-demographics characteristics including age, gender, education, and race/ethnicity. Sensation seeking, a risk factor for substance use (Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002), was assessed via three modified items from the Brief Sensation Seeking Scale: 1) “I like to do frightening things”, 2) “I like new and exciting experiences even if I have to break the rules”, and 3) “I prefer friends who are exciting and unpredictable” (Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002). Response options for each item (strongly agree, agree, neither agree nor disagree, disagree, and strongly disagree) were summed to create an overall score (range: 0–12) and mean score. The scale was found to be internally consistent in the PATH Study (Cronbach’s  $\alpha = 0.76$ ).

**Table 1**  
GAIN-SS items and reliability.

GAIN-SS subscale	Items	Reliability <sup>f</sup>
Substance use problems <sup>a,b</sup>	1) Used alcohol or other drugs weekly or more often 2) Spent a lot of time getting alcohol or other drugs <sup>c</sup> 3) Spent a lot of time using or recovering <sup>c</sup> 4) Alcohol or drugs causing social problems, fights, or trouble with others 5) Reduced involvement with activities at work, school, home, or social events 6) Withdrawal problems <sup>c</sup> 7) Use of alcohol or other drugs to stop being sick or avoid withdrawal problems <sup>c</sup>	Lifetime = 0.85 Past year = 0.82
Internalizing problems <sup>a,d</sup>	1) Feeling very trapped/sad/depressed 2) Trouble sleeping 3) Feeling nervous/anxious/tense/scared 4) Being distressed/upset about the past	Lifetime = 0.81 Past year = 0.79
Externalizing problems <sup>a</sup>	1) Hard time paying attention 2) Hard time listening to instructions 3) Lied/conned to get something 4) Bullied/threatened people 5) Started a physical fight 6) Felt restless/need to climb on things <sup>c</sup> 7) Gave answers before question was finished <sup>c</sup>	Lifetime = 0.77 Past year = 0.73

GAIN-SS: Global Appraisal of Individual Needs - Short Screener (GAIN-SS).

<sup>a</sup> Symptoms were categorized into no/low (0–1 symptoms), moderate (2–3 symptoms), and high (4 symptoms for internalizing problems or  $\geq 4$  symptoms for substance use and externalizing problems) severity levels.

<sup>b</sup> Those who had never used alcohol or drugs were coded as having ‘0’ symptoms

<sup>c</sup> Items 2 and 3, as well as 6 and 7, were separated in the PATH Study.

<sup>d</sup> A fifth suicide item was not included in the PATH Study.

<sup>e</sup> Items 6 and 7 from the full GAIN Behavioral Complexity Scale were included in the PATH Study.

<sup>f</sup> Cronbach’s  $\alpha$  calculated for the PATH Study cutpoints.

### 2.3. Analytic approach

Distributions of participants' demographic characteristics, tobacco use, substance use, and substance use and mental health problems were examined. All variables (except sensation seeking) were categorized for analyses. For the aggregate variables (e.g. any tobacco use), complete data were required to categorize participants as non-users, but not required to categorize participants as users.

Multivariable logistic regression evaluated the associations between tobacco use and substance use, adjusting for socio-demographics (Office of the Surgeon General, 2016) and sensation seeking. Due to potential comorbidity between mental health problems and substance use (Armstrong & Costello, 2002; Kessler et al., 2012), a combined variable for lifetime mental health (internalizing and externalizing) problems categorized as low/moderate (0–7 symptoms) and high (8–11 symptoms) was also included in the substance use regression models. Multivariable logistic regression also modeled the odds of high versus low/moderate substance use, internalizing, and externalizing problems according to tobacco use, adjusting for socio-demographics and sensation seeking.

Distributions of alcohol or any drug use, the combined high severity internalizing and externalizing problem measure, and high severity substance use problems were also examined according to poly-tobacco use. Multivariable logistic regression modeled the odds of alcohol or any drug use according to poly-tobacco use, adjusting for socio-demographics, sensation seeking, and the combined variable for lifetime mental health problems. Multivariable logistic regression also modeled the odds of the combined high severity internalizing and externalizing problem measure, and high severity substance use problems measure, according to any poly-tobacco use, adjusting for socio-demographics and sensation seeking. More detailed analyses can be found in the supplement (see eTables 1 and 2).

Sensitivity analyses were conducted by repeating all analyses using the complete-case method for handling missing data. Post hoc exploratory analyses were conducted to examine if gender moderated the associations between tobacco use and substance use, as well as tobacco use and substance use, internalizing, and externalizing problems.

Estimates were weighted to represent the U.S. youth population; variances and confidence intervals (CIs) were estimated using the balanced repeated replication (BRR) method (McCarthy, 1969) with Fay's adjustment set to 0.3 to increase estimate stability (Judkins, 1990). Adjusted odds ratios (AORs) and 95% CIs were calculated for all regression analyses. Two-sided *p*-values of < 0.05 were considered statistically significant. Estimates based on fewer than 50 observations in the denominator or the relative standard error > 0.30 were suppressed (Klein, Proctor, Boudreault, & Turczyn, 2002). All analyses were conducted using Stata software, version 12 (StataCorp, 2011).

## 3. Results

### 3.1. Demographic and other characteristics

Approximately half of youth were between 12 and 14 years of age (50.4%) and male (51.3%) (Table 2). A third (31.1%) reported ever use of alcohol or any drug; alcohol (21.8%) and marijuana (13.4%) were the most commonly used substances. The proportion of youth with high severity of lifetime substance use problems was relatively low (3.9%), while a larger proportion reported high severity of lifetime internalizing (33.8%) and externalizing (47.1%) problems. The sensation seeking score ranged from 0 to 4 (mean (standard error (SE)) = 1.6 (1.1)).

### 3.2. Tobacco use and substance use

In multivariable analyses (Table 3), ever tobacco use was consistently associated with a higher odds of ever substance use across all

tobacco products assessed. Tobacco users had nearly an 8-fold higher odds of alcohol or any drug use (95% CI: 6.7–8.6) when compared to non-users, after adjusting for socio-demographics, mental health problems, and sensation seeking. Across tobacco products, in comparison to non-users of the respective products, odds of marijuana use was 15-fold (95% CI: 12.4–17.2) for cigarettes, 10-fold for e-cigarettes (95% CI: 8.3–11.3), and 19-fold (95% CI: 15.3–23.4) for cigarillos. Associations across tobacco products with other drug use were also statistically significant and strong, with the strongest association at 19-fold (95% CI: 13.1–27.6) for cigarettes.

**Table 2**  
Demographic and other characteristics of PATH study wave 1 youth, 2013–2014.

Participant characteristics	n <sup>a</sup>	% <sup>b</sup>	SE <sup>b</sup>
Total	13,617	100.0	–
Age (years) <sup>c</sup>			
12–14	6973	50.4	0.02
15–17	6642	49.6	0.02
Gender			
Male	6949	51.3	0.03
Female	6630	48.7	0.03
Race/ethnicity			
White, non-Hispanic	6463	54.6	0.07
Black, non-Hispanic	1798	13.7	0.06
American Indian/Alaska Native, non-Hispanic	70	0.4	0.07
Asian/Native Hawaiian/Other Pacific Islander, non-Hispanic	392	4.7	0.07
Multiple races, non-Hispanic	767	4.2	0.08
Hispanic	3872	22.5	0.05
Education (grade in school)			
5th grade or below	76	0.5	0.07
Middle school (grades 6–8)	5123	37.9	0.23
High school (grades 9–12)	7853	59.6	0.24
College, vocational/technical school	106	0.8	0.09
Not enrolled	32	0.2	0.04
Home-schooled	112	0.8	0.09
Ungraded <sup>d</sup>	14	0.1	0.03
Ever substance use <sup>e</sup>			
Alcohol or any drug	4137	31.1	0.52
Alcohol	2914	21.8	0.52
Marijuana	1837	13.4	0.40
Ritalin/adderall	333	2.5	0.13
Painkillers/sedatives	1087	8.0	0.23
Other drug <sup>f</sup>	219	1.6	0.13
Lifetime substance use problems <sup>g</sup>			
No/low	11,943	90.6	0.31
Moderate	742	5.6	0.23
High	530	3.9	0.21
Lifetime internalizing problems <sup>g</sup>			
No/low	4865	36.5	0.53
Moderate	3956	29.7	0.46
High	4491	33.8	0.57
Lifetime externalizing problems <sup>g</sup>			
No/low	3407	25.7	0.57
Moderate	3538	27.2	0.43
High	6087	47.1	0.58
Sensation seeking score <sup>h</sup>			
Mean (SE)	13,366	1.6	1.10

<sup>a</sup> Represents unweighted sample size (numbers may not sum to the total due to missing data).

<sup>b</sup> Percentages (%) and standard errors (SE) are weighted to represent the US youth population (*N* = 24,791,293).

<sup>c</sup> An age range between 12 and 17 years rather than a specific age was available for two participants.

<sup>d</sup> School where students are not assigned to a particular grade.

<sup>e</sup> Categories are not mutually exclusive (i.e. percentages do not sum to 100%).

<sup>f</sup> Includes ever use of cocaine or crack, stimulants (i.e. methamphetamine or speed), or heroin, inhalants, solvents, or hallucinogens.

<sup>g</sup> Lifetime substance use, internalizing and externalizing problems were assessed using the Global Appraisal of Individual Needs - Short Screener (GAIN-SS) and categorized as no/low (0–1 symptoms), moderate (2–3 symptoms), and high (4 symptoms for internalizing problems or ≥ 4 symptoms for substance use and externalizing problems) severity levels.

<sup>h</sup> Assessed via three modified items from the Brief Sensation Seeking Scale.



**Table 3**  
Ever substance use (%) among ever tobacco users (Y) and non-users (N), PATH study, 2013–2014.

	Alcohol or any drug											
	Alcohol or any drug						Specific alcohol or drug use					
	Alcohol or any drug		Alcohol		Marijuana		Ritalin/adderall		Painkillers/sedatives		Other drugs <sup>a</sup>	
	% (SE) <sup>b</sup>	AOR (95% CI) <sup>c</sup>	% (SE) <sup>b</sup>	AOR (95% CI) <sup>c</sup>	% (SE) <sup>b</sup>	AOR (95% CI) <sup>c</sup>	% (SE) <sup>b</sup>	AOR (95% CI) <sup>c</sup>	% (SE) <sup>b</sup>	AOR (95% CI) <sup>c</sup>	% (SE) <sup>b</sup>	AOR (95% CI) <sup>c</sup>
Any tobacco												
Y	75.1 (0.97)	<b>7.6</b> (6.7–8.6) Referent	61.1 (0.97)	<b>6.5<sup>d</sup></b> (5.7–7.3) Referent	51.2 (1.38)	<b>17.8<sup>d</sup></b> (15.2–20.9) Referent	8.5 (0.57)	<b>6.3</b> (4.7–8.5) Referent	13.5 (0.71)	<b>1.5</b> (1.2–1.7) Referent	6.6 (0.54)	<b>22.3</b> (13.4–37.1) Referent
N	19.9 (0.47)		12.5 (0.45)		3.6 (0.20)		0.8 (0.09)		6.7 (0.26)		0.2 (0.05)	
Cigarettes												
Y	80.1 (1.27)	<b>7.6</b> (6.4–9.1) Referent	65.8 (1.31)	<b>5.6<sup>d</sup></b> (4.8–6.5) Referent	60.8 (1.63)	<b>14.6<sup>d</sup></b> (12.4–17.2) Referent	10.6 (0.74)	<b>5.2<sup>d</sup></b> (4.1–6.7) Referent	16.0 (0.98)	<b>1.7</b> (1.4–2.1) Referent	9.4 (0.76)	<b>19.0</b> (13.1–27.6) Referent
N	24.1 (0.49)		16.0 (0.50)		6.4 (0.28)		1.2 (0.11)		6.9 (0.24)		0.3 (0.06)	
E-cigarettes												
Y	80.1 (1.15)	<b>7.0</b> (6.0–8.3) Referent	66.5 (1.25)	<b>5.4</b> (4.7–6.3) Referent	58.4 (1.32)	<b>9.7</b> (8.3–11.3) Referent	12.5 (0.97)	<b>6.0</b> (4.6–7.9) Referent	14.7 (1.06)	<b>1.5</b> (1.2–1.8) Referent	9.6 (0.88)	<b>9.5</b> (6.8–13.4) Referent
N	25.9 (0.51)		17.5 (0.51)		8.4 (0.35)		1.3 (0.10)		7.4 (0.27)		0.6 (0.08)	
Any cigar												
Y	89.0 (1.04)	<b>12.4</b> (9.8–15.5) Referent	74.7 (1.41)	<b>6.8<sup>d</sup></b> (5.6–8.3) Referent	73.6 (1.65)	<b>16.8</b> (13.9–20.3) Referent	14.2 (1.12)	<b>5.3<sup>d</sup></b> (4.0–7.2) Referent	17.3 (1.23)	<b>1.8</b> (1.4–2.2) Referent	13.0 (1.34)	<b>13.8</b> (9.2–20.6) Referent
N	27.2 (0.51)		18.8 (0.51)		9.0 (0.33)		1.5 (0.12)		7.4 (0.26)		0.6 (0.08)	
Traditional cigars												
Y	85.3 (1.95)	<b>7.1</b> (5.0–10.0) Referent	70.9 (3.05)	<b>4.1</b> (2.9–5.9) Referent	67.9 (3.16)	<b>8.0</b> (5.6–11.3) Referent	17.7 (2.40)	<b>4.2</b> (2.7–6.6) Referent	20.4 (2.43)	<b>2.2</b> (1.6–3.2) Referent	16.3 (2.39)	<b>7.2</b> (4.8–10.8) Referent
N	30.7 (0.55)		21.9 (0.55)		12.6 (0.41)		2.1 (0.13)		7.9 (0.26)		1.2 (0.11)	
Cigarillos												
Y	89.9 (1.16)	<b>13.4</b> (10.2–17.7) Referent	74.8 (1.55)	<b>6.7<sup>d</sup></b> (5.4–8.3) Referent	76.7 (1.79)	<b>18.9</b> (15.3–23.4) Referent	15.2 (1.21)	<b>5.5<sup>d</sup></b> (4.1–7.4) Referent	17.7 (1.35)	<b>1.8</b> (1.5–2.3) Referent	14.3 (1.44)	<b>14.7</b> (10.0–21.7) Referent
N	27.8 (0.53)		19.4 (0.53)		9.5 (0.34)		1.6 (0.12)		7.4 (0.26)		0.7 (0.08)	
Filtered cigars												
Y	92.3 (1.67)	<b>12.6</b> (7.7–20.5) Referent	82.2 (2.78)	<b>7.2</b> (4.7–11.1) Referent	78.8 (2.70)	<b>13.2</b> (9.2–19.1) Referent	19.2 (2.56)	<b>4.7</b> (3.1–7.1) Referent	23.9 (2.66)	<b>2.4</b> (1.8–3.3) Referent	19.3 (2.59)	<b>9.3</b> (6.0–14.2) Referent
N	30.5 (0.54)		21.6 (0.54)		12.4 (0.40)		2.1 (0.13)		7.7 (0.24)		1.1 (0.11)	
Pipe												
Y	87.7 (2.23)	<b>10.0</b> (6.1–16.4) Referent	75.4 (3.32)	<b>6.1</b> (4.1–8.9) Referent	74.1 (3.03)	<b>12.4</b> (8.0–19.2) Referent	16.8 (2.84)	<b>3.9</b> (2.4–6.1) Referent	21.1 (2.99)	<b>2.2</b> (1.5–3.2) Referent	14.3 (2.64)	<b>5.5</b> (3.2–9.4) Referent
N	30.7 (0.53)		21.8 (0.55)		12.7 (0.41)		2.2 (0.13)		7.9 (0.24)		1.3 (0.11)	
Hookah												
Y	84.6 (1.34)	<b>8.0</b> (6.5–9.9) Referent	71.4 (1.48)	<b>5.6<sup>d</sup></b> (4.7–6.7) Referent	65.5 (2.02)	<b>10.3</b> (8.5–12.6) Referent	12.5 (0.99)	<b>4.4</b> (3.4–5.8) Referent	17.0 (1.16)	<b>1.7</b> (1.4–2.0) Referent	9.9 (1.17)	<b>6.7</b> (4.6–9.8) Referent
N	27.4 (0.51)		18.8 (0.51)		9.5 (0.35)		1.6 (0.13)		7.4 (0.24)		0.9 (0.09)	
Smokeless (including snus pouches)												
Y	78.4 (2.12)	<b>5.9</b> (4.6–7.7) Referent	68.1 (2.39)	<b>5.2<sup>d</sup></b> (4.1–6.6) Referent	53.9 (2.82)	<b>6.1</b> (4.7–8.0) Referent	12.4 (1.52)	<b>3.7</b> (2.7–5.0) Referent	15.0 (1.56)	<b>1.7</b> (1.3–2.2) Referent	10.0 (1.50)	<b>5.4</b> (3.4–8.4) Referent
N	29.4 (0.51)		20.5 (0.52)		11.8 (0.39)		2.0 (0.12)		7.8 (0.25)		1.1 (0.12)	

(continued on next page)

Table 3 (continued)

	Alcohol or any drug						Specific alcohol or drug use					
	Alcohol		Marijuana		Ritalin/adderall		Painkillers/sedatives		Other drugs <sup>a</sup>			
	% (SE) <sup>b</sup>	AOR (95% CI) <sup>c</sup>	% (SE) <sup>b</sup>	AOR (95% CI) <sup>c</sup>	% (SE) <sup>b</sup>	AOR (95% CI) <sup>c</sup>	% (SE) <sup>b</sup>	AOR (95% CI) <sup>c</sup>	% (SE) <sup>b</sup>	AOR (95% CI) <sup>c</sup>		
Smokeless (excluding snus pouches)												
Y	79.4 (2.12)	<b>6.1</b> (4.6–8.0) Referent	69.0 (2.39)	<b>5.3</b> (4.1–6.8) Referent	53.6 (2.81)	<b>5.7</b> (4.3–7.4) Referent	13.0 (1.65)	<b>3.8</b> (2.7–5.2) Referent	15.8 (1.68)	<b>1.8</b> (1.4–2.4) Referent	10.6 (1.57)	<b>5.6</b> (3.6–8.7) Referent
N	29.6 (0.52)		20.7 (0.53)		12.0 (0.40)		2.0 (0.12)		7.8 (0.25)		1.2 (0.12)	
Snus pouches												
Y	81.1 (0.0366)	<b>5.8</b> (3.4–9.9) Referent	70.2 (4.21)	<b>4.5</b> (2.8–7.0) Referent	61.4 (4.24)	<b>6.6</b> (4.3–10.0) Referent	15.7 (2.95)	<b>3.6</b> (2.1–6.2) Referent	17.8 (2.70)	<b>2.0</b> (1.4–3.1) Referent	11.1 (2.50)	†
N	31.0 (0.0052)		22.0 (0.0053)		13.0 (0.0040)		2.2 (0.0013)		8.0 (0.0026)		1.4 (0.0012)	Referent
Kreteks												
Y	89.7 (4.07)	†	78.3 (6.59)	†	82.4 (5.59)	†	20.9 (5.98)	†	33.4 (7.69)	†	35.4 (7.18)	†
N	31.7 (0.54)	Referent	22.7 (0.55)	Referent	13.6 (0.42)	Referent	2.4 (0.14)	Referent	8.1 (0.24)	Referent	1.4 (0.12)	Referent
Bidis												
Y	†	†	†	†	†	†	†	<b>4.8</b> (1.7–13.7) Referent	†	†	†	†
N	31.7 (0.54)	Referent	22.8 (0.55)	Referent	13.7 (0.42)	Referent	2.4 (0.14)	Referent	8.1 (0.24)	Referent	1.5 (0.12)	Referent
Dissolvable												
Y	†	†	†	†	†	†	†	NR	†	†	†	†
N	31.8 (0.54)	Referent	22.8 (0.55)	Referent	13.8 (0.42)	Referent	2.4 (0.13)	Referent	8.1 (0.24)	Referent	1.5 (0.13)	Referent

Statistically significant associations at p < 0.05 indicated in bold text.

NR: estimates not reportable due to model convergence issues.

<sup>a</sup> Includes ever use of cocaine or crack, stimulants (i.e. methamphetamine or speed), or heroin, inhalants, solvents, or hallucinogens.

<sup>b</sup> Percentages (%) and standard errors (SE) are weighted to represent the US youth population.

<sup>c</sup> Adjusted Odds Ratios (AORs) and 95% confidence intervals (CIs) from multivariable logistic regression analyses adjusted for age, gender, race/ethnicity, lifetime mental health (internalizing and externalizing) problem symptoms, and sensation seeking.

<sup>d</sup> Indicates gender interaction is significant at p < 0.05.

† Estimates with a denominator < 50 or relative standard error > 30% were suppressed.



Although not systematic across tobacco products, gender moderated several associations between tobacco use and substance use. In all cases where this occurred, female tobacco users were more likely to use substances than male tobacco users. Specifically, female cigarette users were more likely than male cigarette users to use alcohol, marijuana, and Ritalin/Adderall. Additionally, for any tobacco product, any cigar, cigarillos, hookah, and smokeless tobacco (including snus pouches), female users were more likely to use alcohol than their male counterparts.

### 3.3. Tobacco use and substance use and mental health problems

Multivariable logistic regression models (Table 4) showed strong

and consistent associations between ever tobacco use and high severity lifetime substance use problems. Tobacco users had an almost 20-fold (95% CI: 14.9–26.0) higher odds of substance use problems compared to non-users. Across tobacco products, the strongest associations were observed for cigarette (AOR = 14.7, 95% CI: 11.8–18.2), cigarillo (AOR = 8.1, 95% CI: 6.3–10.3), and filtered cigar (AOR = 8.1, 95% CI: 5.7–11.5) users, compared to non-users of those products, respectively.

The magnitude of associations for internalizing and externalizing problems varied by tobacco product, with ever cigarette, e-cigarette, traditional cigar, cigarillo, and filtered cigar use each significantly associated with both internalizing and externalizing problems, after adjusting for socio-demographics and sensation seeking. The strongest associations were observed for cigarette (AOR = 1.7, 95% CI: 1.5–2.0)

**Table 4**  
High severity (%) of lifetime substance use, internalizing, and externalizing problems among ever tobacco users (Y) and non-users (N), PATH study, 2013–2014.

	High severity substance use problems <sup>a</sup>		Mental health problems			
			High severity internalizing problems <sup>a</sup>		High severity externalizing problems <sup>a</sup>	
	% (SE) <sup>b</sup>	AOR (95% CI) <sup>c</sup>	% (SE) <sup>b</sup>	AOR (95% CI) <sup>c</sup>	% (SE) <sup>b</sup>	AOR (95% CI) <sup>c</sup>
Any tobacco						
Y	16.0 (0.82)	<b>19.7</b> (14.9–26.0)	48.3 (0.95)	<b>1.6<sup>d</sup></b> (1.4–1.8)	61.3 (1.06)	<b>1.4</b> (1.3–1.6)
N	0.6 (0.09)	Referent	30.5 (0.66)	Referent	43.8 (0.64)	Referent
Cigarettes						
Y	21.4 (1.18)	<b>14.7</b> (11.8–18.2)	51.9 (1.28)	<b>1.7<sup>d</sup></b> (1.5–2.0)	63.7 (1.27)	<b>1.5</b> (1.3–1.7)
N	1.2 (0.10)	Referent	31.3 (0.58)	Referent	44.8 (0.60)	Referent
E-cigarettes						
Y	20.4 (1.22)	<b>8.0</b> (6.5–9.9)	50.5 (1.41)	<b>1.6<sup>d</sup></b> (1.3–1.8)	64.8 (1.38)	<b>1.5</b> (1.3–1.7)
N	1.9 (0.14)	Referent	32.1 (0.60)	Referent	45.3 (0.59)	Referent
Any cigar						
Y	25.6 (1.57)	<b>9.5</b> (7.4–12.3)	49.0 (1.39)	<b>1.4<sup>d</sup></b> (1.2–1.7)	64.8 (1.64)	<b>1.4<sup>d</sup></b> (1.2–1.7)
N	2.2 (0.17)	Referent	33.0 (0.62)	Referent	46.2 (0.58)	Referent
Traditional cigars						
Y	26.9 (2.89)	<b>5.8</b> (4.1–8.3)	48.9 (3.03)	<b>1.4</b> (1.1–1.9)	67.6 (3.07)	<b>1.5</b> (1.1–2.1)
N	3.4 (0.20)	Referent	33.9 (0.59)	Referent	47.1 (0.57)	Referent
Cigarillos						
Y	25.7 (1.68)	<b>8.1</b> (6.3–10.3)	48.4 (1.68)	<b>1.4<sup>d</sup></b> (1.2–1.7)	64.3 (1.88)	<b>1.4</b> (1.2–1.7)
N	2.4 (0.17)	Referent	33.2 (0.61)	Referent	46.3 (0.58)	Referent
Filtered cigars						
Y	34.3 (3.18)	<b>8.1</b> (5.7–11.5)	56.0 (3.23)	<b>1.7</b> (1.3–2.3)	70.8 (2.78)	<b>1.8</b> (1.3–2.4)
N	3.2 (0.19)	Referent	33.7 (0.58)	Referent	47.0 (0.57)	Referent
Pipe						
Y	32.1 (3.53)	<b>7.2</b> (5.0–10.6)	49.4 (3.79)	<b>1.4</b> (1.0–1.9)	61.2 (3.96)	<b>1.1</b> (0.7–1.6)
N	3.4 (0.19)	Referent	33.8 (0.57)	Referent	47.2 (0.58)	Referent
Hookah						
Y	22.7 (1.65)	<b>6.4</b> (5.0–8.1)	47.5 (1.46)	<b>1.2<sup>d</sup></b> (1.0–1.4)	59.1 (1.62)	<b>1.1</b> (1.0–1.3)
N	2.4 (0.16)	Referent	33.0 (0.61)	Referent	46.4 (0.61)	Referent
Smokeless (including snus pouches)						
Y	18.8 (1.53)	<b>4.7</b> (3.5–6.1)	43.5 (1.96)	<b>1.2<sup>d</sup></b> (1.0–1.4)	61.9 (1.75)	<b>1.2</b> (0.9–1.5)
N	3.2 (0.20)	Referent	33.6 (0.58)	Referent	46.7 (0.60)	Referent
Smokeless (excluding snus pouches)						
Y	18.6 (1.57)	<b>4.3</b> (3.2–5.8)	44.5 (2.03)	<b>1.2<sup>d</sup></b> (1.0–1.5)	62.2 (1.88)	<b>1.2</b> (0.9–1.5)
N	3.2 (0.21)	Referent	33.6 (0.58)	Referent	46.7 (0.60)	Referent
Snus pouches						
Y	23.8 (3.48)	<b>5.0</b> (3.3–7.7)	42.4 (3.33)	<b>1.1</b> (0.8–1.5)	63.2 (3.35)	<b>1.2</b> (0.9–1.7)
N	3.6 (0.20)	Referent	33.9 (0.58)	Referent	47.1 (0.59)	Referent
Kreteks						
Y	37.7 (7.28)	†	48.4 (8.46)	†	70.7 (6.53)	†
N	3.8 (0.21)	Referent	34.1 (0.57)	Referent	47.4 (0.59)	Referent
Bidis						
Y	†	†	†	†	†	†
N	3.8 (0.21)	Referent	34.1 (0.57)	Referent	47.4 (0.59)	Referent
Dissolvable						
Y	†	NR	†	†	†	†
N	3.9 (0.22)	Referent	34.1 (0.57)	Referent	47.4 (0.59)	Referent

Statistically significant associations at p < 0.05 indicated in bold text.

NR: estimates not reportable due to model convergence issues.

<sup>a</sup> Includes ever use of cocaine or crack, stimulants (i.e. methamphetamine or speed), or heroin, inhalants, solvents, or hallucinogens.

<sup>b</sup> Percentages (%) and standard errors (SE) are weighted to represent the US youth population.

<sup>c</sup> Adjusted Odds Ratios (AORs) and 95% confidence intervals (CIs) from multivariable logistic regression analyses adjusted for age, gender, race/ethnicity, lifetime mental health (internalizing and externalizing) problem symptoms, and sensation seeking.

<sup>d</sup> Indicates gender interaction is significant at p < 0.05.

† Estimates with a denominator < 50 or relative standard error > 30% were suppressed.

and filtered cigar (AOR = 1.7, 95% CI: 1.3–2.3) users for internalizing problems, and filtered cigar users (AOR = 1.8, 95% CI: 1.3–2.4) for externalizing problems. Results were virtually unchanged when analyses were repeated using the complete case method for handling missing data.

Similar to the tobacco and substance use associations, a significant gender-by-tobacco use interaction was seen across most tobacco product use groups for internalizing problem associations, which were stronger among female tobacco users than male tobacco users. In comparison, no gender differences were found for substance use problems or externalizing problems, with the exception of female cigar users being more likely to have externalizing problems than male cigar users.

### 3.4. Poly-tobacco use and substance use and mental health problems

Fig. 1 presents the proportions of alcohol or any drug use, high severity mental health problems, and high severity substance use problems among poly-tobacco users of any tobacco product versus exclusive users of any tobacco product. Poly-tobacco users were more likely to use alcohol or any drug than exclusive users (AOR = 3.4, 95% CI: 2.7–4.3). Further, poly-tobacco users had a nearly 5-fold higher odds (95% CI: 3.4–6.6) of having substance use problems in comparison to exclusive tobacco users. While the prevalence of internalizing and externalizing problems was higher among poly-tobacco users in comparison to exclusive users, the strength of the association was not as pronounced as for substance use and substance use problems (AOR = 1.2, 95% CI: 1.0–1.5). No significant gender interactions were seen for these associations.

## 4. Discussion

This is one of few studies to comprehensively examine co-occurrence of substance use and mental health problems across tobacco-product user groups and among poly-tobacco users in a nationally representative sample of U.S. youth. Findings indicate that youth tobacco users, in comparison to non-users, are more likely to use substances and have substance use problems. Moreover, these associations were robust across the 12 tobacco products assessed, as well as for poly-tobacco use. Tobacco users were also more likely to experience internalizing and externalizing problems. Notably, gender moderated the associations between tobacco use, substance use, and mental health problems. These findings have important implications for understanding substance use and mental health problems among youth tobacco users, as well as emphasizing the need to address these comorbidities in clinical and public health settings.

As documented previously (Ramo, Liu, & Prochaska, 2012; Richter et al., 2017), our findings show robust tobacco and substance use associations across tobacco products, particularly between filtered cigar and alcohol. The strong association between cigarillo and marijuana use was also striking and may point to the simultaneous use of tobacco and marijuana (e.g., blunts) as a risk pattern for continued use, addiction and associated medical consequences (Bélanger et al., 2013; Ramo et al., 2012). Considering the rapidly changing policies surrounding marijuana legalization and the emergence of non-cigarette tobacco products, the increased availability and use of these products by youth (Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2017) represent a public health concern that warrants further attention.

Results were equally striking for associations between tobacco product use and substance use problems. The strongest association for substance use problems was found among cigarette users, which suggests that cigarette use may be a clinically useful indicator of problematic substance use (Office of the Surgeon General, 2016). This study also demonstrates that users of e-cigarettes, traditional cigars, cigarillos, filtered cigars, hookah, and smokeless tobacco are more likely to experience internalizing problems compared to their non-using

counterparts, thereby extending prior research that focused primarily on cigarette smoking (Marmorstein et al., 2010; Marmorstein, White, Loeber, et al., 2010; Mistry, Babu, Mahapatra, & McCarthy, 2014; Zehe, Colder, Read, Wieczorek, & Lengua, 2013). While the association between cigarette use and externalizing problems has been established among youth (Armstrong & Costello, 2002; Colder et al., 2013; National Center for Chronic Disease Prevention and Health Promotion (US) Office on and Smoking Health, 2012), this study extends the literature for youth filtered cigar, e-cigarette, traditional cigar, and cigarillo users. Our finding of increased risk regardless of tobacco product points to nicotine as a common denominator of potential etiological significance in understanding the interplay between mental health and substance use problems. However, we cannot rule out that these associations may also be driven by a shared environmental, familial, or genetic diathesis representing a common underlying factor for tobacco use, substance use, and mental illness. Future analysis of the PATH Study's longitudinal data can examine whether youth who use tobacco products are more or less likely to develop or exacerbate mental health problems.

Additionally, consistent with recent findings using 2014 data from the National Survey on Drug Use and Health (NSDUH) and the Monitoring the Future (MTF) study (Richter et al., 2017) and extending to mental health problems, poly-tobacco users were more likely to use alcohol and drugs and have substance use and mental health problems than exclusive tobacco users. Although these comorbidities are frequently documented, few prevention and intervention strategies address tobacco use within the same framework as substance use and mental health. Given the high prevalence of poly-tobacco use (Kasza et al., 2017; Richter et al., 2017; Villanti et al., 2016) and poly-substance use (Connor, Gullo, White, & Kelly, 2014) among youth, our findings support and reinforce the need for timely and comprehensive interventions and treatment that effectively address these co-occurring conditions (Camenga & Klein, 2016).

While exploratory, the gender differences in tobacco, substance use, and mental health comorbidities observed in this study warrant further attention. In all occurrences of gender-by-tobacco use interactions, female tobacco users were more likely to use substances than male tobacco users, particularly for cigarette users. Associations with alcohol use were also stronger for female non-cigarette tobacco product users compared to their male counterparts and across tobacco products, female users were more likely to have internalizing problems than males. These findings are consistent with the co-occurrence of these behaviors among adults (Conway et al., 2017), suggesting that female tobacco

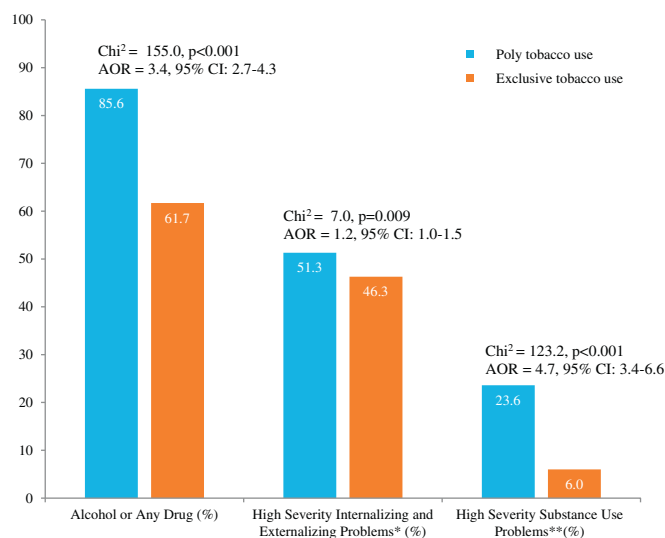


Fig. 1. Ever substance use (%) and lifetime high severity mental health problems (%) among youth poly-tobacco ever users versus exclusive ever tobacco users, PATH study, 2013–2014.

product users may be on an increased trajectory of risk for substance use and mental health problems beginning in adolescence, and effective interventions and treatment tailored to females are critical at a young age to prevent these disparities persisting into adulthood.

Although Wave 1 data from the PATH Study are nationally representative, harmonized with other national studies, and focus on multiple tobacco products, this study has limitations. The GAIN-SS measures severity of mental-health symptomology rather than diagnosis. However, the high sensitivity and specificity between GAIN-SS items and diagnoses supports the use of symptoms as good indicators of clinically significant mental-health problems (M. L. Dennis, et al., 2006). Additionally, some items from the GAIN-SS were omitted from the PATH Study's Wave 1 instrument, thereby limiting the ability to assess their associations with tobacco use. Given the instrument design, we were not able to assess whether cigarillo users were also using cigarillos modified as a blunt at the same time or other instances, potentially explaining the large odds ratios observed for those associations. Furthermore, while testing interactions with demographic variables aside from gender were beyond the scope of this study, future studies may explore comorbidities across different subgroups defined by demographics (e.g., age, race/ethnicity), which can provide additional insight into the associations observed in this study. Finally, while the cross-sectional Wave 1 data preclude the establishment of temporality, future longitudinal data of the PATH Study will help clarify the temporal ordering between youth tobacco use, substance use, and substance use and mental health problems.

## 5. Conclusions

The present study documents high co-occurrence of alcohol and drug use, as well as substance use and mental health problems, across tobacco products in a nationally representative sample of U.S. youth. These findings also point to youth tobacco use, especially cigarette and poly-tobacco use, as a potential indicator of treatment need for substance use problems. Researchers and health-care providers should consider comprehensive assessments of tobacco use, substance use, and mental health problems to identify vulnerable youth for prevention and early intervention efforts, and effective treatments should take into account and address these comorbidities.

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## Contributors

Drs. Conway and Compton conceptualized and designed the study and approved the final manuscript as submitted. Dr. Conway and Ms. Green drafted the initial manuscript, and Ms. Green approved the final manuscript as submitted. Ms. Kasza carried out the analyses, reviewed and revised the manuscript, and approved the final manuscript as submitted. Dr. Silveira performed quality assurance and control of the analyses, reviewed and revised the manuscript, and approved the final manuscript as submitted. All others, including Drs. Borek, Kimmel, Sargent, Stanton, Reissig, Jackson, Tanski, Maklan, and Hyland, as well as Ms. Lambert and Hilmi reviewed and approved the initial proposed analyses, reviewed and revised the manuscript, and approved the final manuscript as submitted.

## Conflict of interest disclosures

W.M. Compton declares ownership of stock in General Electric Co, 3M Co, and Pfizer Inc, unrelated to the submitted work. No other

potential conflicts of interest were reported.

## Disclaimer

The views and opinions expressed in this manuscript are those of the authors only and do not necessarily represent the views, official policy or position of the US Department of Health and Human Services or any of its affiliated institutions or agencies.

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