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Correlates of tobacco product initiation among youth and young adults between Waves 1 - 4 of the

Population Assessment of Tobacco and Health (PATH) Study (2013-2018)

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1   **ABSTRACT**

2   **Introduction:** While risk factors for cigarette smoking among youth and young adults are well-

3   documented, less is known about the correlates of initiation of other tobacco products. This study aims

4   to provide estimates and correlates of initiation among U.S. youth and young adults.

5   **Methods:** Data on youth aged 12-17 (n=10,072) and young adults aged 18-24 (N=5,727) who provided

6   information on cigarettes, electronic nicotine delivery systems (ENDS), cigars, pipe, hookah and

7   smokeless tobacco use in Wave 1 (W1: 2013-2014)-Wave 4 (W4: 2016-2018) of the nationally-

8   representative PATH Study were used to calculate ever use initiation and correlates of initiation by W4.

9   **Results:** Nearly 6 million youth and 2.5 million young adults used tobacco for the first time between W1-

10   W4. Approximately one quarter of youth and young adult ENDS never users initiated ENDS between W1-

11   W4 of the PATH Study. Among youth, use of other tobacco products, ever substance use, and high

12   externalizing problems were associated with initiation of most products. Among young adults, use of

13   other tobacco products and ever substance use were associated with initiation of most products. In both

14   youth and young adults, Hispanics were more likely to initiate hookah use than their non-Hispanic White

15   counterparts. While male sex was a risk factor for most tobacco product initiation across both age

16   groups, it was not associated with hookah initiation.

17   **Conclusions:** Cigarette and non-cigarette products shared many correlates of initiation, although there

18   are noteworthy demographic differences. Findings can help tailor product specific interventions to reach

19   populations at risk during preliminary stages of use.

20 **1. INTRODUCTION**

21   Cigarette smoking usually begins in youth and young adulthood; few U.S. adult daily cigarette

22   smokers began smoking after age 25.[1] While the prevalence of cigarette smoking in the U.S. has declined

23   over time,[1] nationally-representative, cross-sectional estimates from the National Youth Tobacco Survey

24   (NYTS), the National Health Interview Survey (NHIS) and Monitoring the Future (MTF) have shown that

25   use of some non-cigarette products such as electronic nicotine delivery systems (ENDS) has risen

26   dramatically in recent years, particularly among youth and young adults.[1-3] However, there is currently

27   little research published from longitudinal studies reporting incidence and risks factors for initiation

28   among two groups with high use estimates, youth and young adults.

29   Although stages of use have not been defined for many non-cigarette products, the underlying

30   stages in the pathway from never use to established use of cigarettes have been defined as progression

31   from non-use preparation stages such as susceptibility, followed by initiation/trial, experimentation,

32   regular use to established use.[4] In this paper we focus on new use (initiation) among 1) never users of

33   each individual product (never product-specific users at Wave 1 [W1]) and 2) those who had never used

34   any type of tobacco products (tobacco-naïve at W1). From a public health perspective, information is

35   needed on factors that predict initiation of individual products to determine the impact of public health

36   regulatory actions on non-users and the likelihood of use of each product.[5]

37   Correlates of cigarette smoking have been summarized previously,[6,7] and although longitudinal

38   data on correlates of non-cigarette use are growing,[8-10] more research on other non-cigarette products

39   such as ENDS, cigars, pipe, hookah and smokeless tobacco, and factors associated with initiation can

40   help researchers and policy makers target interventions. Many studies in youth found that

41   demographics, previous tobacco use, previous substance use, familial and peer influences, and mental

42   health problems are associated with cigarette smoking,[4,6] but fewer studies have examined these factors

43   across multiple tobacco products in the same sample of individuals longitudinally. The exception is Kasza

44   et al., who recently documented correlates of initiation across products through Wave 3 [W3] of the

45   PATH Study, finding that previous tobacco use consistently predicted tobacco product initiation, and

46   some demographic predictors (sex, race/ethnicity and sexual orientation) varied across products.[11]

47   Other studies have found that correlates of non-cigarette products have included alcohol use,[12,13]

48   exposure to others using the products, [14-16] mental health,[9] peer use,[7] and receptivity to tobacco

49   advertising.[8]

50   The aim of this study is to expand upon previous PATH Study analyses[5,8,9,11,14,17-20] by presenting

51   population estimates of tobacco product initiation and correlates of initiation of each product among

52   youth and young adults between W1 (2013-2014) and Wave 4 (W4, 2016-Jan 2018). Specifically, this

53   study adds to the current literature by providing estimates through a more recent follow-up period and

54   including a larger number of potential correlates. Understanding commonalities and differences

55   between tobacco products, not just in demographic characteristics, but also psychosocial risk factors for

56   new tobacco use may help researchers and public health analysts prevent future tobacco use by

57   focusing on the most frequently used new products and unique risk factors for use of each product.

58   **2. METHODS**
59   The PATH Study is a large, nationally representative, longitudinal study of tobacco use and

60   health among youth and adults in the U.S. A detailed description of the PATH Study design and

61   methodology has been published elsewhere.[21] Details on interviewing procedures, questionnaires,

62   sampling, weighting, response rates, and accessing the data are described in the *PATH Study Restricted*

63   *Use Files User Guide* at https://doi.org/10.3886/Series606. The study was conducted and approved by

64   Westat and the Westat Institutional Review Board. All respondents ages 18 and older provided informed

65   consent, with youth respondents ages 12 to 17 providing assent while each one's parent/legal guardian

66   provided consent.

67   The PATH Study W2-W4 data collection protocols followed procedures to interview each

68   respondent close to the 1-year anniversary of their participation in the prior wave. Interviews were

69   sometimes conducted earlier or later, due to varying circumstances, including respondents' schedules,

70 time needed to contact respondents, and grouping of multiple respondents within a household, thus

71 resulting in some variance in time between interviews (means for youth and adults at each wave ranged

72 from 50 to 54 weeks). Data collection was conducted from September 2013 to December 2014 (W1),

73 October 2014 to October 2015 (W2), October 2015 to October 2016 (W3) and December 2016 to

74 January 2018 (W4). At W1, an additional "shadow sample" of youth ages 9 to 11 was selected to be

75 interviewed at later waves when they aged up to 12 years and is referred to throughout this manuscript

76 as "shadow youth." See more details at https://doi.org/10.3886/Series606.

77   Supplemental Table 1 shows weighted response rates (conditional upon W1 participation).

78 Differences in the number of completed interviews between W1 and subsequent waves reflect attrition

79 (e.g., nonresponse, mortality) and the aging of shadow youth to youth and of youth to adults. The

80 unweighted attrition rates among the entire W1 sample (adults and youth combined) are 16% at W2,

81 21% at W3, and 27% at W4.

82 **2.1 Study Population**
83   The current study analyzes data from the restricted use files (RUF) among all young adults and

84 youth. The sample includes W1 youth ages 12-17 years (n=10,072) and W1 young adults ages 18-24

85 years (n=5,727) who provided information on tobacco use at W1 through W4. Age groups are defined by

86 a participant's age at baseline W1. Participants were excluded from the final analysis if their reported

87 age at W2 was younger than their reported age at baseline, if there was a difference of more than two

88 years in self-reported age between W1 and W2 (n=14 youth, n=12 young adults), or they were lost to

89 follow up in the following waves (n=1,906 youth, n=1,582 young adults). Supplemental Table 4 presents

90 information on a subset of W3 youth and young adults (based on W3 age) in order to present initiation

91 estimates for the latest two waves of youth and young adult data available (W3 and W4).

92 **2.2 Tobacco Use Measures**
93   At baseline, all respondents were asked a series of questions regarding ever use of the following

94 tobacco products: cigarettes, ENDS, traditional cigars, cigarillos, filtered cigars, pipe, hookah, snus

95   pouches, other smokeless tobacco (e.g., loose snus, moist snuff, dip, spit, chewing tobacco), and

96   dissolvable tobacco. Product images and brief descriptions, including common brand names, were

97   provided to aid respondents (available at http://doi.org/10.3886/ICPSR36231). Youth were asked about

98   bidis and kreteks use, but adults were not; therefore, these products were excluded from the analysis,

99   unless otherwise specified.

100   At each follow-up wave all continuing respondents were asked if they had used each product in

101   the past 12 months (initiation). The PATH Study instrument was updated, and questions were changed

102   from asking about e-cigarettes to asking about all ENDS products between W1 and W2. However, for

103   clarity, only the term "ENDS" is used throughout this manuscript.

104   Construction of variables is described in Appendix A.

105   **2.4 Statistical Analysis**
106   Full-sample and replicate weights were created that adjust for the complex sample design (e.g.,

107   oversampling at W1) and nonresponse at W1-W4. PATH Study W1 Cohort weighted estimates represent

108   the U.S. resident population ages 12 years and older at the time the specific data examined were

109   collected (i.e., W1, W2, W3, or W4) who were in the civilian, noninstitutionalized population at W1. This

110   analysis used W4 all-waves weights to obtain statistically valid estimates from longitudinal analyses that

111   examine W1 Cohort data across all waves, 1 through 4. In-depth information about the design of the W1

112   Cohort is also available at https://doi.org/10.3886/Series606.

113   All initiation estimates and risk ratios for correlates were calculated using the follow-up

114   longitudinal population and replicate weights that adjusted for the complex study design characteristics

115   (e.g., oversampling at W1) and nonresponse in SAS (version 9.4) survey procedures for proportions and

116   SAS-callable SUDAAN (version 11.0.3) for logistic regressions.

117   Where presented, variances and 95% Wilson confidence intervals (CIs) of the estimates were

118   calculated using balanced repeated replication (BRR) weights with Fay's adjustment of 0.3. All estimates

119   with an unweighted denominator <50 or a relative standard error (RSE) ≥30% were flagged. Weighted

120 multiple logistic regressions modeled the associations between correlates and initiation use of each

121 tobacco product. Significance level was set at p<0.05.

122 We conducted a sensitivity analysis to understand the role of missing covariates on the results.

123 The percentage of missing covariates ranged by product from 12.0% to 14.1% among youth and from

124 7.8% to 8.4% among young adults. Specifically, this sensitivity analysis used multiple imputation and

125 includes three steps: (1) We imputed five datasets without missing covariates using fully conditional

126 specification method with an arbitrary missing data pattern; (2) We analyzed the five datasets using our

127 original analysis; and (3) We combined the results from the 5 datasets using the traditional approach by

128 Rubin (1987) and Barnard and Rubin (1999).[22,23]

129 **3. RESULTS**
130 Overall, nearly 6.0 million (32.5%) youth and approximately 2.5 million (25.9%) young adult W1

131 never tobacco users initiated any tobacco use by W4 (Supplemental Table 2). Among W1 never users of

132 each product, initiation was highest for ENDS in youth (26.7%) and young adults (25.0%) (Figure 1,

133 Supplemental Table 2). In youth, among W1 never users of each specific product, prevalence of

134 initiation in descending order was ENDS, followed by cigarettes (15.8%), cigars (14.4%), hookah (11.8%),

135 smokeless tobacco (6.0%) and pipe (2.6%). Comparatively, in young adults, the order was ENDS,

136 followed by hookah (16.0%), cigars (15.0%), cigarettes (13.5%), pipe (3.4%) and smokeless tobacco

137 (3.3%). Initiation of dissolvable tobacco was less than 1% in both youth and young adults. In general, by

138 W4, the percent of new product use was higher among youth and young adults who had ever used

139 tobacco at W1 than tobacco naïve youth and young adults at W1; however, weighted n's of some

140 products were higher due to larger denominators among never users (Supplemental Table 3).

141 Supplemental Table 4 shows weighted estimates for initiation of each product from W3 to W4

142 (among youth and young adults in W3). Like the W1-W4 estimates, initiation in youth was highest for

143 ENDS (6.6%), followed by cigarettes (4.3%), cigars (3.6%), hookah (1.7%), smokeless tobacco (1.4%) and

144 pipe (0.6%). In young adults from W3-W4, similar estimates of young adult nonusers initiated use of

145   cigarettes (5.8%), ENDS (5.5%) and cigars (5.0%), followed by hookah (3.9%), smokeless tobacco (1.6%)

146   and pipe (1.0%).

147   Table 1 shows adjusted risk ratios of associations between correlates and tobacco use initiation

148   from W1-W4 weighted logistic regression models among youth. Male youth were more likely than

149   females to initiate cigarettes, ENDS, cigars, pipe and smokeless tobacco; however, female youth were

150   more likely than males to initiate hookah. Youth ages 15-17 years (vs. 12-14 years) were more likely to

151   initiate cigarettes, ENDS, cigars or hookah but there was no association between age and pipe or

152   smokeless tobacco initiation. Compared to non-Hispanic White youth, non-Hispanic Black youth were

153   less likely to be initiators of cigarettes, ENDS, pipe and smokeless tobacco but no association was seen

154   with hookah or cigars. Hispanic youth were less likely than non-Hispanic White youth to initiate ENDS,

155   cigars, pipe tobacco and smokeless tobacco but more likely to initiate hookah (no association was seen

156   with cigarettes). Previous use of other tobacco products and ever alcohol use was associated with

157   initiation by W4 for each individual tobacco product. Ever marijuana use was associated with initiation

158   of cigarettes, ENDS, cigars and hookah, but no association was seen with pipe or smokeless tobacco.

159   Past year psychosocial problems, specifically high severity externalizing problems (such as having a hard

160   time paying attention, lying to get what you want and starting a physical fight), were associated with

161   initiation of all products except pipe, while high severity internalizing problems (such as depression,

162   anxiety, and trouble sleeping) were only associated with ENDS initiation. Exposure to tobacco use in the

163   household or exposure to others who smoked cigarettes in the past seven days was associated with

164   initiation of cigarette, ENDS, and cigars. Household use but not exposure to others who smoked

165   cigarettes in the past 7 days was associated with smokeless tobacco initiation.

166   Table 2 shows adjusted results from W1-W4 weighted logistic regression models among young

167   adults. Young adult males were more likely to initiate each product except hookah than females and

168   young adults ages 18-20 years (vs. 21-24 years) were more likely to initiate each tobacco product. Non-

169 Hispanic Blacks were more likely than non-Hispanic Whites to initiate cigars or hookah, but non-Hispanic

170 Whites were more likely to initiate smokeless tobacco. Hispanics were more likely to initiate cigarettes,

171 ENDS, hookah and less likely to use smokeless tobacco than non-Hispanic Whites. Previous tobacco use

172 was associated with new initiation of each product. Ever alcohol and ever marijuana use were

173 associated with initiation of cigarettes, ENDS, cigars and hookah, but no association was seen with pipe

174 or smokeless tobacco. Household exposure to tobacco and exposure to other smokers in the past seven

175 days was associated with initiation of ENDS. Exposure to household tobacco use was associated with

176 smokeless tobacco and pipe initiation.

177 Results from the sensitivity analysis using multiple imputation for the missing covariates yielded

178 similar results as the complete case analysis. Therefore, the original complete case analysis was

179 presented in the tables.

180 **4. DISCUSSION**
181 This study provides national estimates of tobacco product initiation and correlates of initiation

182 from W1-W4 of the PATH Study among youth and young adults. Most youth and young adults who were

183 tobacco-naïve in W1 remained tobacco naïve over four-year follow-up. However, the absolute number

184 of new tobacco users among youth and young adults is considerable: among never users of any product

185 in W1 of the PATH Study, nearly 6 million youth (32.5%) and an estimated 2.5 million young adults

186 (25.9%) in the U.S. used a tobacco product for the first time by W4. This represents approximately 5,400

187 youth and 2,300 young adult never tobacco users who initiated tobacco product *use each* day during

188 three waves of follow-up W2-W4 (approximately 3 years).

189 In youth, the products with the highest overall initiation from W1-W4 were ENDS, followed by

190 cigarettes, any cigar (including traditional cigars, cigarillos and filtered cigars), hookah, any smokeless

191 and traditional pipe. In young adults, after ENDS, the highest overall initiation was seen for hookah,

192 cigars, and cigarettes followed by pipe and smokeless tobacco. Consistent with results from MTF, new

193 ENDS use among youth and young adults was higher than new cigarette use in W1-W4,[24] however

194   cigarette, cigar, and hookah initiation in W1-W4 was over 10% in both youth and young adults,

195   suggesting combustible tobacco product use is still an important public health problem.

196   We also examined whether previously identified correlates of cigarette smoking were consistent

197   for initiation of non-cigarette products. In youth, the majority of our findings are in line with factors

198   previously associated with tobacco use and initiation.[6,11] Our findings suggest although males are at

199   higher risk for initiation of most products, except for hookah where females were at higher risk. This

200   suggests that sex should be considered in hookah education and prevention programs . In addition, our

201   analyses show in both youth and young adults, previous tobacco use, alcohol or marijuana use is

202   associated with new product initiation for most products. This finding is consistent with previous

203   literature and highlights users of alcohol, marijuana and other tobacco products as an at-risk population

204   for new tobacco product initiation.

205   We found psychosocial problems were associated with initiation of most products in youth, but

206   not young adults. Previous PATH Study analyses of tobacco-naïve youth in W1-W2 found past year

207   internalizing (such as depression, anxiety, and trouble sleeping) and externalizing (such as having a hard

208   time paying attention, lying to get what you want and starting a physical fight) problems were

209   associated with ENDS only initiation, and externalizing problems were associated with cigarette

210   initiation or dual (cigarette/ENDS) initiation.[25] Our work confirms that, in youth, both internalizing and

211   externalizing problems are associated with ENDS initiation, and externalizing problems are associated

212   with cigarette initiation, although our sample was not limited to tobacco-naïve youth. Our study extends

213   previous work by finding externalizing problems were also associated with cigar, hookah and smokeless

214   tobacco initiation in youth. We did not see any association between tobacco product initiation and

215   internalizing or externalizing problems among young adults in our study. The results of our study are

216   different than a separate W1-W2 PATH paper which found lifetime internalizing and externalizing

217   problems were associated with initiation in youth and young adults,[9] but we used past-year internalizing

218   and externalizing problems.

219   While other studies have found an association between the exposure to friends or household

220   members using tobacco products and ENDS and cigarettes,[26] our study expands upon the finding that

221   exposure to tobacco use by others (household and exposure to others smoking) is an important risk

222   factor for cigarettes and ENDS but also cigars in youth, and household use is an important risk factor for

223   initiation of any smokeless tobacco in youth. Our study did not find an association between these

224   factors for cigarettes in young adults, but did for ENDS, and found household use was a risk factor for

225   smokeless tobacco and pipe initiation in young adults.

226   For individual products, our findings were consistent with previous studies that have shown

227   similarities between risk factors and correlates of use for cigarettes and ENDS, including exposure to

228   others using the products, psychosocial variables and use of alcohol or marijuana.[14-16] Similar to previous

229   studies, we found alcohol use was associated with new hookah use in youth and young adults,[12] as was

230   marijuana and previous tobacco use. [27] For smokeless tobacco, consistent with other studies of youth,

231   alcohol use was associated with new smokeless tobacco use,[13] although the same was not true of young

232   adults. Few studies have examined initiation of cigars in youth, although our study found correlates of

233   initiation for cigars was similar to those of cigarettes.

234   This study found racial and ethnic demographic differences in tobacco product initiation

235   correlates in U.S. youth and young adults during this time period. First, Hispanics in both age groups

236   were more likely to initiate hookah use than their non-Hispanic White counterparts, a finding that has

237   been documented previously among youth.[11] Hispanic young adults were also more likely than their

238   non-Hispanic counterparts to initiate ENDS and cigarettes. Non-Hispanic Black young adults were more

239   likely to initiate cigar use than their non-Hispanic White counterparts. Taken together, these differences

240   by race/ethnicity can inform health messaging that is targeted to young populations at high risk for

241   tobacco initiation. Conversely, Non-Hispanic Black youth are at a lower risk for initiation for almost all

242   tobacco products compared to their Non-Hispanic White counterparts. Future studies examining why

243   Black adolescents delay use could help us understand how to better foster delay in other groups.

244   Consistent with Kasza et al., previous tobacco use was associated with initiation of all products

245   in youth and young adults.[11] This may be due to initiation of one tobacco product decreasing perceived

246   harm and increasing susceptibility and willingness to try other products,[28] or due to a higher risk profile

247   for initiation among those initiating multiple products. In general, many correlates of initiation of non-

248   cigarette products were similar to previously identified correlates that were mainly based on cigarette

249   smoking, but this study allows for examination and comparison of these correlates across the other five

250   products. This implies that prevention messages targeted to those aspects should have wide impact

251   across all products.

252   We found many young adults already tried tobacco products at W1, leading to a reduced size of

253   young adults at risk for new tobacco product use. Young adults who reach young adulthood without

254   ever having tried a certain tobacco product may be fundamentally different from those youth who

255   experiment for the first time before age 18; those most susceptible to tobacco may initiate at a younger

256   age, which may modify the underlying risk profile of the young adults eligible for the analysis.

257   Furthermore, a smaller number of observations in the young adult sample may have affected our ability

258   to detect differences in the young adult sample, especially in adjusted models. However, it is important

259   to note that young adults ages 18-20 years were more likely to initiate tobacco use than young adults

260   ages 21-24 years. The 18–20-year-old age group is important to continue to monitor given the national

261   law passed in 2019 that raised the minimum age for sale of tobacco products from 18 to 21 years. The

262   timeframe of our study was before the passage of this law, but future studies can continue to monitor

263   initiation rates in these youngest adults (18-20 years) who now are underage consumers.

264   A strength of our study is that we were able to stratify the sample by tobacco-naïve never users

265   at baseline, allowing us to isolate youth and young adults who reported no use of each product, and

266   those who were completely tobacco-naïve at W1. We found higher initiation in those who previously

267   used another tobacco product than the tobacco-naïve. However, some limitations should be considered

268   when interpreting these findings. Given the rise in the popularity of JUUL-like devices,[29] estimates of

269   new use could be higher in the PATH Study after January 2018. In order to facilitate comparison across

270   models for each of the tobacco products, parsimonious models were not developed with covariates

271   known to be correlated with each product, and some of the models may be over specified.[30] In addition,

272   since correlates were measured at W1, our analysis does not take into account for the any time-varying

273   component of these risk factors over the course of the study period. Finally, we did not adjust the

274   significance threshold for multiple comparisons primarily because the adjustment may be conservative

275   for the number of comparisons made, and we did not want to overlook possibly interesting findings

276   because of the multiplicity adjustment that reduces the Type I error and thus increases the probability

277   of Type II error.[31,32]

278   As few studies have examined initiation and correlates of use across multiple products using the

279   same measures, these findings may help researchers and public health analysts focus on the most

280   frequently used new products and common risk factors. Information on youth correlates of non-

281   cigarette products expands upon previously known factors associated with new cigarette smoking.

282   Future research can examine other long-term trajectories of use over multiple waves, including

283   switching between tobacco products or adding products, longitudinal changes in frequency of product

284   use, and product-specific correlates. Expanded data on behavioral use transitions can be used to update

285   inputs to population health models. Furthermore, estimates of initiation by product and correlates of

286   initiation could be used to monitor and tailor product-specific prevention messages and intervention

287   campaigns for the identified demographic groups at higher risk.

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FIGURE 1: PATH Study New Use by Wave 4 (2016-Jan 2018) Among Wave 1 (2013-2014) Never Users of Each Product
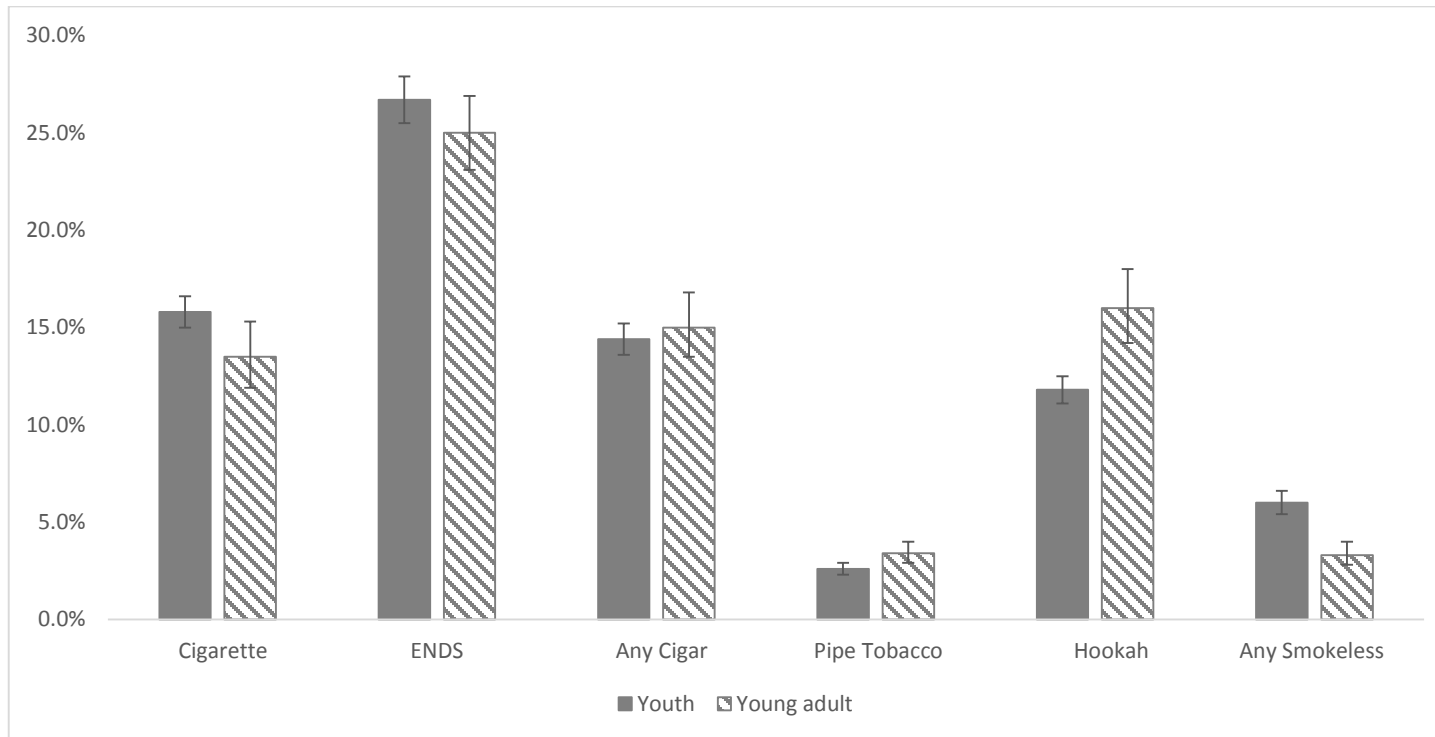
[1] A number of W1 youth never users of a product were missing item-level data for tobacco use status at W2-W4 (n=14 cigarette, n=48 ENDS, n=67 any cigar, n=44 pipe tobacco, n=26 hookah, n=181 any smokeless tobacco). A number of W1 young adult never users of a product were missing item-level data for tobacco use status at W2-W4 (n<5 cigarette, n=37 ENDS, n=0 any cigar, n<5 pipe tobacco, n<5 hookah, n=12 any smokeless tobacco).

[2] This figure includes youth (12-17 years) and young adults (18-24 years) who had never used the specific product in question but may have used other products in the past.

[3] Raw n's, weighted n's and weighted percentages are available in Supplemental Table 2.

[4] Any cigar use = respondents who had ever used any of the three types of cigars (traditional cigars, cigarillos, and filtered cigars)

[5] Any smokeless tobacco use = respondents who had ever used either snus pouches or other smokeless tobacco, not including dissolvable tobacco (which was asked as a separate category)

[6] Due to the small number of new dissolvable tobacco users at W4, dissolvable tobacco has been removed from the figure.

TABLE 1: Factors Associated with Initiation by PATH Study W4 among W1 Youth Never Users, by Tobacco Product

Wave 1	Adjusted Relative Risk (95% Confidence Interval) of W2-W4 Initiation					
	Cigarettes 1,326 Initiators [1]	ENDS 2,278 Initiators [2]	Any Cigar 1,223 Initiators [3]	Pipe Tobacco 244 Initiators [4]	Hookah Use 1,035 Initiators [5]	Any Smokeless 510 Initiators [6]
Demographics						
Male vs. Female	**1.2** (1.1-1.4)	**1.2** (1.1-1.3)	**1.8** (1.6-2.0)	**2.3** (1.7-3.1)	**0.9** (0.8-1.0)	**3.4** (2.7-4.3)
Age 15-17 years vs. 12-14 years	**1.5** (1.3-1.7)	**1.2** (1.1-1.3)	**2.3** (2.0-2.7)	1.3 (1.0-1.7)	**2.6** (2.2-3.0)	1.1 (0.9-1.3)
Race/ethnicity[7]: NH Black vs. NH White	**0.6** (0.5-0.7)	**0.6** (0.5-0.7)	1.1 (0.9-1.4)	**0.2** (0.1-0.5)	1.1 (0.9-1.4)	**0.3** (0.2-0.5)
Hispanic or Latino vs. NH White	0.9 (0.8-1.1)	**0.9** (0.8-1.0)	**0.8** (0.7-0.9)	**0.6** (0.4-0.8)	**1.3** (1.1-1.5)	**0.4** (0.3-0.6)
NH AI or AN or more than one race vs. NH White	**0.7** (0.6-0.9)	**0.8** (0.7-0.9)	**0.7** (0.6-0.9)	1.0 (0.6-1.6)	1.2 (1.0-1.5)	**0.3** (0.2-0.5)
Previous Substance Use at W1						
Previous vs. No Tobacco Use	**1.8** (1.6-2.1)	**1.6** (1.4-1.8)	**1.6** (1.4-1.9)	**3.6** (2.3-5.7)	**1.6** (1.3-1.9)	**2.5** (2.0-3.2)
Ever vs. Never Alcohol Use	**1.5** (1.3-1.8)	**1.7** (1.5-1.8)	**1.7** (1.5-2.0)	**1.6** (1.1-2.3)	**1.8** (1.6-2.1)	**1.4** (1.1-1.8)
Ever vs. Never Marijuana Use	**1.5** (1.3-1.8)	**1.4** (1.2-1.6)	**1.6** (1.3-1.8)	1.1 (0.8-1.6)	**1.6** (1.3-2.0)	1.1 (0.8-1.4)
Psychosocial (High GAIN Subscale Score)						
Substance Use	1.0 (0.6-1.6)	**1.5** (1.1-2.1)	1.1 (0.8-1.6)	1.4 (0.9-2.3)	1.3 (0.9-1.8)	1.4 (0.9-2.2)
Internalizing	1.1 (0.9-1.3)	**1.2** (1.1-1.3)	1.1 (1.0-1.2)	0.7 (0.5-1.1)	0.9 (0.8-1.1)	0.9 (0.7-1.1)
Externalizing	**1.4** (1.2-1.6)	**1.3** (1.2-1.4)	**1.3** (1.1-1.5)	1.3 (0.9-1.8)	**1.2** (1.1-1.4)	**1.3** (1.1-1.7)
Exposure to Other's Use of Tobacco						
Household use	**1.3** (1.1-1.4)	**1.2** (1.1-1.3)	**1.2** (1.1-1.4)	1.0 (0.7-1.3)	1.0 (0.9-1.2)	**1.6** (1.2-2.0)
Others smoking in the past 7 days	**1.3** (1.2-1.5)	**1.2** (1.1-1.3)	**1.2** (1.1-1.3)	**1.4** (1.0-2.0)	1.1 (1.0-1.3)	1.2 (0.9-1.5)

Each Relative Risk (RR) is adjusted for all other factors in the table; RR in bold represents statistically significantly more (if the RR>1) or fewer (if the RR<1) new users for the tobacco product for the group vs. the reference group; Due to rounding up or rounding down, some RRs are statistically significant even if their 95% CIs appear to include 1.

[1] n=145 new W2-W4 past 12-month cigarette users were missing covariates and were not included in the model.

[2] n=262 new W2-W4 past 12-month ENDS users were missing covariates and were not included in the model.

[3] n=98 new W2-W4 past 12-month any cigar users were missing covariates and were not included in the model.

[4] n=30 new W2-W4 past 12-month pipe users were missing covariates and were not included in the model.

[5] n=112 new W2-W4 past 12-month hookah users were missing covariates and were not included in the model.

[6] n=63 new W2-W4 past 12-month any smokeless tobacco users were missing covariates and were not included in the model.

[7] NH = Non-Hispanic; AI = American Indian; AN = Alaskan Native, Asian, Native Hawaiian, other Pacific Islander

[8] Any cigar use = respondents who had ever used any of the three types of cigars (traditional cigars, cigarillos, and filtered cigars).

[9] Any smokeless tobacco use = respondents who had ever used either snus pouches or other smokeless tobacco, not including dissolvable tobacco (which was asked as a separate category).

[10] Due to the small number of new dissolvable tobacco users at W4 dissolvable tobacco has been removed from the table, although dissolvable tobacco remains one of the products included in the any tobacco use and other tobacco use variables.

TABLE 2: Factors Associated with Initiation by PATH Study W4 among W1 Young Adult Never Users, by Product

Wave 1	Adjusted Relative Risk (95% Confidence Interval) of W2-W4 Initiation					
	Cigarettes 329 Initiators[1]	ENDS 979 Initiators[2]	Any Cigar 475 Initiators[3]	Pipe Tobacco 208 Initiators[4]	Hookah Use 488 Initiators[5]	Any Smokeless 175 Initiators[6]
Demographics						
Male vs. Female	**1.6** (1.3-2.1)	**1.2** (1.0-1.3)	**1.7** (1.4-2.1)	**2.4** (1.6-3.5)	1.1 (0.9-1.4)	**3.8** (2.5-5.8)
Age 18-20 years vs. 21-24 years	**2.1** (1.6-2.7)	**1.6** (1.4-1.8)	**1.4** (1.1-1.7)	**1.6** (1.1-2.3)	**1.6** (1.3-2.0)	**1.9** (1.3-2.8)
Race/ethnicity[7]: NH Black vs. NH White	1.2 (0.8-1.7)	0.9 (0.7-1.1)	**1.7** (1.3-2.2)	0.9 (0.6-1.3)	**2.1** (1.7-2.7)	**0.4** (0.3-0.7)
Hispanic or Latino vs. NH White	**1.5** (1.2-2.0)	**1.2** (1.1-1.4)	0.9 (0.7-1.1)	1.2 (0.8-1.7)	**1.6** (1.2-2.2)	**0.6** (0.4-0.9)
NH AI or AN or more than one race vs. NH White	0.9 (0.6-1.5)	1.1 (0.8-1.5)	0.7 (0.5-1.1)	0.9 (0.5-1.8)	1.5 (1.0-2.3)	**0.5** (0.3-1.0)
Previous Substance Use at W1						
Previous vs. No Tobacco Use	**1.5** (1.2-2.0)	**2.5** (2.0-3.2)	**2.2** (1.6-2.8)	**5.0** (1.9-13.0)	**1.4** (1.0-1.9)	**2.2** (1.0-4.8)
Ever vs. Never Alcohol Use	**1.5** (1.1-2.0)	**1.2** (1.0-1.5)	**1.3** (1.0-1.7)	0.9 (0.5-1.5)	**1.8** (1.3-2.5)	1.0 (0.6-1.7)
Ever vs. Never Marijuana Use	**1.4** (1.0-1.9)	**1.2** (1.1-1.5)	**1.4** (1.1-1.7)	0.8 (0.6-1.2)	**1.7** (1.2-2.3)	1.1 (0.7-1.6)
Psychosocial (High GAIN Subscale Score)						
Substance Use	**3.1** (2.1-4.7)	**1.3** (1.0-1.7)	1.3 (0.8-2.1)	**2.6** (1.6-4.3)	1.4 (0.8-2.3)	**1.8** (1.0-3.2)
Internalizing	1.3 (0.9-1.7)	1.0 (0.8-1.2)	1.0 (0.7-1.3)	0.7 (0.4-1.1)	1.1 (0.8-1.4)	0.7 (0.4-1.2)
Externalizing	0.7 (0.5-1.0)	1.1 (0.9-1.4)	1.1 (0.8-1.4)	1.1 (0.7-1.8)	1.0 (0.7-1.3)	1.1 (0.7-1.8)
Exposure to Other's Use of Tobacco						
Household use	1.2 (0.9-1.6)	**1.2** (1.1-1.4)	1.0 (0.8-1.3)	**1.4** (1.0-2.0)	0.9 (0.7-1.1)	**1.7** (1.2-2.6)
Others smoking in the past 7 days	1.3 (1.0-1.7)	**1.3** (1.1 -1.5)	1.1 (0.9-1.3)	1.5 (1.0-2.4)	1.2 (0.9-1.5)	1.4 (0.9-2.4)

Each Relative Risk (RR) is adjusted for all other factors in the table; RR in bold represents statistically significantly more (if the RR>1) or fewer (if the RR<1) new users for the tobacco product for the group vs. the reference group; Due to rounding up or rounding down, some RRs are statistically significant even if their 95% CIs appear to include 1.

[1] n=21 new W2-w4 past 12-month cigarette users were missing covariates and were not included in the model.
[2] n=71 new W2-W4 past 12-month ENDS users were missing covariates and were not included in the model.
[3] n=34 new W2-W4 past 12-month any cigar users) were missing covariates and were not included in the model.
[4] n=20 new W2-W4 past 12-month pipe users were missing covariates and were not included in the model.
[5] n=39 new W2-W4 past 12-month hookah users were missing covariates and were not included in the model.
[6] n=9 new W2-W4 past 12-month any smokeless users were missing covariates and were not included in the model.
[7] NH = Non-Hispanic; AI = American Indian; AN = Alaskan Native, Asian, Native Hawaiian, other Pacific Islander
[8] Any cigar use = respondents who had ever used any of the three types of cigars (traditional cigars, cigarillos, and filtered cigars)

[9] Any smokeless tobacco use = respondents who had ever used either snus pouches or other smokeless tobacco, not including dissolvable tobacco (which was asked as a separate category)

[10] Due to the small number of new dissolvable tobacco users at W4 dissolvable tobacco has been removed from the table, although dissolvable tobacco remains one of the products included in the any tobacco use and other tobacco use variables.

SUPPLEMENTAL TABLE 1: Unweighted sample sizes and weighted response rates[a] for the PATH Study W1 Cohort by data collection wave

Wave	Youth Interview			Adult Interview		
(Dates)	Aged-up youth (N)	Total n[a]	Response Rate[b,c]	Aged-up adults (N)	Total n[a]	Response Rate[b,c]
Wave 1[d] (09/12/13–12/14/14)	---	13,651	78.4%	---	32,320	74.0%
Wave 2 (10/23/14–10/30/15)	2,091	12,172	87.3%	1,915	28,362	83.2%
Wave 3 (10/19/15–10/23/16)	2,045	11,814	83.3%	1,907	28,148	78.4%
Wave 4 (12/01/16-01/03/18)	1,694	11,059	79.5%	1,900	27,757	73.5%

[a]Total n includes aged-up youth (shadow youth who turned 12 and were eligible for the youth interview) and aged-up adults (youth who turned 18 and were eligible for the adult interview). (The age range for eligible youth was 12 to 17 years; the age range for eligible adults was 18 years and older. Note this table reports response rates for all adults, while the focus population of this manuscript is young adults 18 to 24 years old.

[b]W1 weighted response rates are among households with completed screeners; W2-W4 response rates are conditional on participation at W1.

[c]Weighted attrition rates for W2-W4 correspond to 100 minus the weighted response rate for each interview type (i.e., youth, adult).

[d]At W1, the weighted response rate for the household screener was 54.0%. Among households screened, the overall W1 weighted response rate was 74.0% for the adult interview and 78.4% for the youth interview. Future wave weighted response rates are conditional upon W1 participation.

SUPPLEMENTAL TABLE 2: Initiation by PATH Study W4 among W1 Never Users for Different Tobacco Products

		Tobacco product	Number of users (numerator)	Weighted Estimated number of users	Estimated percent (weighted)	95% CI	
Youth	Initiation at any point between W2-W4 since W1	Any tobacco	2,385	5,955,000	32.5	31.2	33.7
		Cigarette	1,326	3,368,000	15.8	15.0	16.6
		ENDS	2,278	5,835,000	26.7	25.5	27.9
		Any cigar	1,223	3,169,000	14.4	13.6	15.2
		Pipe	244	617,000	2.6	2.3	2.9
		Hookah	1,035	2,689,000	11.8	11.1	12.5
		Any smokeless tobacco	510	1,363,000	6.0	5.4	6.6
		Dissolvable	42	101,000	0.4	0.3	0.6
Young adults	Initiation at any point between W2-W4 since W1	Any tobacco	319	2,521,000	25.9	22.7	29.3
		Cigarette	329	1,917,000	13.5	11.9	15.3
		ENDS	979	5,030,000	25.0	23.1	26.9
		Any cigar	475	2,417,000	15.0	13.5	16.8
		Pipe	208	892,000	3.4	2.9	4.0
		Hookah	488	2,684,000	16.0	14.2	18.0
		Any smokeless tobacco	175	837,000	3.3	2.8	4.0
		Dissolvable	48	210,000	0.7	0.5	1.0

[1]A number of W1 youth never users of a product were missing item-level data for tobacco use status at W2-W4 (n= 179 any tobacco, n=14 cigarette, n=48 ENDS, n=67 any cigar, n=44 pipe tobacco, n=26 hookah, n=181 any smokeless tobacco, n=42 dissolvable tobacco). A number of W1 young adult never users of a product were missing item-level data for tobacco use status at W2-W4 (n=7 any tobacco, n<5 cigarette, n=37 ENDS, n=0 any cigar, n<5 pipe tobacco, n<5 hookah, n=12 any smokeless tobacco, n=14 dissolvable tobacco)

[2] This table rounds weighted numbers down to the nearest thousandth.

[3] This table includes youth (12-17 years) and young adults (18-24 years) who had never used the specific product in question but may have used other products in the past.

[4] Any cigar use = respondents who had ever used any of the three types of cigars (traditional cigars, cigarillos, and filtered cigars)

[5] Any smokeless tobacco use = respondents who had ever used either snus pouches or other smokeless tobacco, not including dissolvable tobacco (which was asked as a separate category)

SUPPLEMENTAL TABLE 3: Initiation by W4 stratified by never-ever any tobacco use status at W1 in the PATH Study

		Tobacco product	W1 Ever Use Any Tobacco				W1 Never Use Any Tobacco			
			Number of users (numerator)	Estimated number of users	Estimated percent	95% CI	Number of users (numerator)	Estimated number of users	Estimated percent	95% CI
Youth	Past 12-month initiation at any point between W2-W4 since W1	Any tobacco	NA				2,385	5,955,000	32.5	(31.2-33.7)
		Cigarette	277	744,000	40.5	(36.7-44.5)	1,009	2,532,000	13.5	(12.8-14.3)
		ENDS	548	1,467,000	59.1	(54.8-63.3)	1,674	4,220,000	22.6	(21.5-23.8)
		Any cigar	425	1,135,000	35.7	(32.5-39.0)	784	1,994,000	10.7	(10.0-11.5)
		Pipe	140	359,000	7.8	(6.6-9.2)	99	243,000	1.3	(1.0-1.6)
		Hookah	370	986,000	29.6	(26.9-32.4)	644	1,647,000	8.8	(8.1-9.5)
		Any smokeless tobacco	202	575,000	15.0	(12.9-17.3)	299	765,000	4.2	(3.7-4.6)
		Dissolvable	25	61,000	1.2	(0.7-2.0)	16	38,000	0.2	(0.1-0.3)
Young adults	Past 12-month initiation at any point between W2-W4 since W1	Any tobacco	NA				319	2,521,000	25.9	(22.7-29.3)
		Cigarette	194	893,000	21.1	(17.7-24.8)	131	987,000	10.1	(8.5-11.9)
		ENDS	834	3,852,000	37.4	(35.0-39.8)	143	1,154,000	11.9	(9.8-14.4)
		Any cigar	350	1,479,000	23.7	(21.1-26.6)	124	932,000	9.5	(7.8-11.5)
		Pipe	198	809,000	5.0	(4.3-5.8)	10	83,000	0.9*	(0.4-1.6)
		Hookah	338	1,525,000	22.5	(19.8-25.3)	147	1,128,000	11.5	(9.4-14.0)
		Any smokeless tobacco	157	673,000	4.5	(3.8-5.3)	18	163,000	1.7	(1.0-2.7)
		Dissolvable	45	182,000	0.9	(0.7-1.3)	3	27,000	0.3*	(0.1-0.9)

*Relative standard error is greater than 30%.

[1] This table rounds weighted numbers down to the nearest thousandth.

[2] Any cigar use = respondents who had ever used any of the three types of cigars (traditional cigars, cigarillos, and filtered cigars).

[3] Any smokeless tobacco use = respondents who had ever used either snus pouches or other smokeless tobacco, not including dissolvable tobacco (which was asked as a separate category).

[4] The age range for eligible youth was 12 to 17 years; the age range for eligible adults was 18 to 24 years.

Supplemental Table 4: Past 12-month Initiation by W4 among W3 Never Tobacco Users, by product

	Tobacco product	Number of users (numerator)	Weighted Estimated number of users	Estimated percent (weighted)	95% CI	
Youth	Cigarette	415	959,000	4.3	3.9	4.8
	ENDS	542	1,357,000	6.6	6.0	7.3
	Any cigar	337	822,000	3.6	3.2	4.0
	Pipe tobacco	56	135,000	0. 6	0.4	0.7
	Hookah	159	387,000	1.7	1.4	2.0
	Any smokeless	136	329,000	1.4	1.2	1.7
	Dissolvable	13	25,000	0.1	0.06	0.2
Young adults	Cigarette	226	842,000	5.8	5.0	6.7
	ENDS	208	790,000	5.5	4.6	6.5
	Any cigar	247	781,000	5.0	4.3	5.8
	Pipe tobacco	75	264,000	1.0	0.8	1.4
	Hookah	170	625,000	3.9	3.2	4.8
	Any smokeless	103	388,000	1.6	1.2	2.1
	Dissolvable	15	55,000	0.2	0.1	0.3

[1]A number of W3 youth never users of a product were missing item-level data for tobacco use status at W4 (n=9 cigarette, n=14 ENDS, n=30 any cigar, n=16 pipe tobacco, n=11 hookah, n=34 any smokeless tobacco, n=15 for dissolvable tobacco). A number of W3 young adult never users of a product were missing item-level data for tobacco use status at W4 (n<5 cigarette, n<5 ENDS, n=5 any cigar, n<5 pipe tobacco, n<5 hookah, n=6 any smokeless tobacco, n=8 for dissolvable tobacco)

[2]This table rounds weighted numbers down to the nearest thousandth.

[3] Any cigar use = respondents who had ever used any of the three types of cigars (traditional cigars, cigarillos, and filtered cigars)

[4] Any smokeless tobacco use = respondents who had ever used either snus pouches or other smokeless tobacco, not including dissolvable tobacco (which was asked as a separate category)

[5] 95% CIs for new past 12-month use are represented in the table.

[6] This table includes youth and young adults who had never used the specific product in question but may have used other products in the past.

Like the full sample, these respondents who participated through W1-W4, provided information about tobacco use at W3, had follow-up data for tobacco use at W4, and whose age at W4 was no more than 2 years older than that at W3 (n=10,616 youth, n=7,141 young adults). The number of youth participants in W3-W4 is slightly higher than the total number of participants in W1-W4 due to youth under the age of 12 (shadow youth) becoming eligible to answer questions at age 12 and 13 in W3.

Appendix A: Creation of Variables

Construction of Initiation Variables

Use of any tobacco product and use of each of seven product classes (cigarette, ENDS, any cigar [traditional cigar, cigarillos, filtered cigars], any smokeless tobacco [snus pouches or non-snus pouch smokeless tobacco], pipe tobacco, hookah, dissolvable tobacco) were assessed at baseline. At follow-up, initiation (new use in the past 12 months) of each tobacco product was assessed among those who had never used the tobacco product at baseline as well as among tobacco-naïve individuals. Any individual who had not used a product before baseline but reported new use after or during follow-up was considered to have initiated that product.

Those who had never heard of or never used each tobacco product at W1 were considered never users of that product. At each wave of W2-W4, any tobacco use, use of the seven product classes, and polytobacco product use were calculated for the past 12 months. At each wave, any tobacco use was defined as use of any of the seven tobacco product classes. Any cigar use was constructed such that if a respondent had ever used any of the three types of cigars (traditional cigars, cigarillos, and filtered cigars), they were counted as an any cigar user. Any smokeless tobacco use was constructed in a similar manner: if respondents had ever used either snus pouches or other smokeless tobacco, not including dissolvable tobacco (which was asked as a separate category), they were categorized as an any smokeless tobacco user. For any tobacco, any cigar or any type of smokeless tobacco, complete product response information was required to categorize participants as non-users of each product but was not required to categorize participants as any tobacco users. Individual product use (cigarette, ENDS, pipe tobacco, hookah, dissolvable tobacco) was calculated based on responses to questions about that specific product at each wave. Missing data for individual product use was based on missing responses to that particular question.

New past 12-month use of any tobacco was calculated as the proportion of never users of any tobacco product at W1 who used any tobacco product in the past 12 months at each wave of W2-W4. New past 12-month use of each tobacco product for seven classes of tobacco products was calculated as the proportion of never users of a specific tobacco product at W1 who reported initiation of that tobacco product in the past 12 months at each wave of W2-W4.

Initiation of each tobacco product for seven classes of tobacco products was calculated as the proportion of never users of a specific tobacco product at W1 who reported initiation of that tobacco product by W4.

Correlates

Demographic correlates included age, sex, and race/ethnicity. Missing data on demographics and education were imputed as described in the PATH Study Restricted Use Files User Guide (United States Department of Health and Human Services 2019). Household exposure to tobacco use was explored by assessing cigarette smoking and tobacco use among household members, as well as any exposure to others smoking within the past seven days. Ever use of marijuana and alcohol were assessed. Internalizing factors (depression, anxiety, distress, and trouble sleeping) and externalizing factors (having a hard time paying attention, having a hard time listening to directions, lying to get what you want, bullied or threatened others, started a physical fight, felt restless, and answered before the other person finished asking the question) were also assessed. Severity of substance abuse symptoms, internalizing, and externalizing were assessed using subscales of the Global Appraisal of Individual Needs Short Screener (GAIN-SS).[1] Problems experienced within the past 12 months were tallied and dichotomized by severity, with four or more problems reported in the past 12 months categorized as a high substance use, internalizing, and externalizing disorder score.

Sensation-seeking variables and academic performance were not available in the young adult cohort and were therefore not included in these analyses in order to ensure consistency across age groups.

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[1] Dennis ML, Chan YF, Funk RR. Development and validation of the GAIN Short Screener (GSS) for internalizing, externalizing and substance use disorders and crime/violence problems among adolescents and adults. *Am J Addict.* 2006;15 Suppl 1:80-91.

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