**Pain is associated with E-Cigarette Use and Dependence in Young Adults: Findings from Wave 7 (2022 – 2023) of the Population Assessment of Tobacco and Health (PATH) Study**

**Abstract**

**Background.** Use of electronic cigarettes (e-cigarettes) among young adults (i.e., individuals aged 18 – 24) has increased substantially in recent years. Consistent with an established reciprocal model of pain and substance use, evidence demonstrates that pain increases risk for initiation and continued use of e-cigarettes, as well as dual use of e-cigarettes and other tobacco products. Meta-analytic findings also indicate that many young adults experience chronic pain (~12%); however, we are not aware of any prior research examining associations between pain, e-cigarette use, and dependence among young adults.

**Method.** Data was drawn from 10,267 young adults (68% White; 50% Female) aged 18 – 24 who participated in Wave 7 (2022 – 2023) of the Population Assessment of Tobacco and Health (PATH) Study.

**Results.** Logistic regression models indicated that moderate/severe pain (vs. no/low pain) was associated with greater odds of lifetime, current, and daily e-cigarette use. Moderate/severe pain was associated with greater odds of exclusive e-cigarette use, exclusive use of other tobacco products, and dual use of e-cigarettes and other tobacco products. Linear regression analyses further revealed that moderate/severe pain was positively associated with tobacco dependence.

**Conclusion.** These findings suggest that moderate/severe pain may serve as a risk factor for e-cigarette use, dependence, and dual e-cigarette and other tobacco product use among young adults. Future prospective research is needed to clarify temporal precedence in the onset of moderate/severe pain and e-cigarette use among young adults. Clinical interventions focused on e-cigarette prevention and cessation among young adults with chronic pain may also be warranted.

*Keywords: young adults, e-cigarettes, pain, nicotine, tobacco, dependence, co-use*

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The use of electronic nicotine devices (hereinafter referred to as e-cigarettes, which are the most commonly used electronic nicotine device; [1]) has increased substantially in recent years [2], particularly among young adults. Americans aged 18 to 25 are more likely to use e-cigarettes compared to other age groups, with 2023 estimates indicating that nearly a quarter (24%) used e-cigarettes in the past month [3], and more than 1 in 10 (13%) reported current, established e-cigarette use (i.e., regular or habitual usage patterns; [4]). E-cigarettes contain toxicants and irritants [5], and their use has been linked to adverse effects on respiratory and cardiovascular health [6,7]. Dependence symptoms (i.e., cravings, tolerance, and negative reinforcement; [8,9]) are common among people who use e-cigarettes, and more than 80% of young adults who use e-cigarettes report at least one symptom of nicotine dependence [8]. This is notable, as individuals with greater nicotine dependence engage in heavier usage patterns and are less likely to quit e-cigarette use [10,11]. Furthermore, while some may use e-cigarettes as a healthier smoking alternative [6], the majority of e-cigarette using young adults, including 72% aged 18 – 20 and 53% aged 21 – 24, have never smoked cigarettes [12], and the use of e-cigarettes has been linked with subsequent initiation of cigarette smoking among non-smoking young adults [13,14]. Approximately 68% of individuals who use e-cigarettes also report past 30-day use of other tobacco products [15], and individuals who engage in dual tobacco product use tend to report greater nicotine dependence [16] and are more likely to transition to exclusive use of combustible tobacco cigarettes [17], compared to those who use a single tobacco product. Thus, identifying factors associated with e-cigarette use, dependence and dual product use among young adults is essential for guiding effective prevention and cessation strategies.

The presence of pain, including chronic pain (i.e., pain lasting 3 or more months, or beyond the expected healing time; [18], has gained increased clinical and empirical attention as an important correlate of nicotine or tobacco product use [19,20]. A reciprocal model of pain and substance use proposes bidirectional relationships between pain and the use of nicotine and tobacco products, resulting in escalations in both pain and nicotine use [20–22]. Consistent with this perspective, meta-analytic evidence indicates that nicotine produces acute analgesic effects [23], which may amplify positive reinforcement of nicotine. Conversely, cross-sectional and prospective findings demonstrate that pain increases risk for both the initiation and maintenance of e-cigarette use among the general adult population [24,25], and greater pain severity has been associated with greater e-cigarette dependence, perceived difficulty quitting, and negative abstinence expectancies [26,27]. Notably, pooled random-effect prevalence data indicates that 12% of individuals aged 15 – 34 experience chronic pain [28], and young adults with pain experience unique challenges (i.e., the transition from pediatric to adult healthcare services, difficulty with key developmental milestones; [29,30]]) which may increase their vulnerability to engage in maladaptive coping strategies, including tobacco use [31].Indeed, pain has been linked to both cigarette smoking [32] and the use of smokeless tobacco products [33] among young adult populations. However, there is a paucity of research examining associations between pain and e-cigarette use and dependence among young adults.

Using data from Wave 7 (2022 – 2023) of the Population Assessment of Tobacco and Health (PATH) Study, the present analysis sought to test the following hypotheses: among young adults, the presence of moderate to severe pain will be associated with greater odds of (a) lifetime e-cigarette use; (b) current, established e-cigarette use; (c) current, established daily e-cigarette use. Further, we hypothesized that moderate to severe pain would be associated with greater odds of exclusive e-cigarette use and dual use of e-cigarettes and other tobacco products. Among individuals who engage in current, established e-cigarette use, we hypothesized that moderate to severe pain would be associated with higher scores on a measure of e-cigarette dependence.

**Method**

**Participants and Data Source**

The Population Assessment of Tobacco and Health (PATH) study is an ongoing longitudinal, nationally representative cohort study of the civilian, non-institutionalized population of U.S. adults and youth, which is administered by the National Institute on Drug Abuse, the National Institutes of Health, the United States Food and Drug Administration’s Center for Tobacco Products, and Westat. The PATH study employed an address-based, stratified area-probability sample design. Data were drawn from Wave 7 (2022 – 2023) of the PATH study, which were collected using a mix of telephone, Web based, and in-person interviews, conducted in English or Spanish. Full details about the PATH study design and methodology can be found elsewhere [34], and data underlying the current analyses can be accessed at the National Addiction and HIV Data Archive Program: [*https://www.icpsr.umich.edu/web/NAHDAP/stud ies/36498*](https://www.icpsr.umich.edu/web/NAHDAP/stud%20ies/36498). All respondents ages 18 and older provided informed consent. Participants aged 18 – 24 were classified as young adults, which is consistent with an established definition of young adulthood [35]. Further, the age variable provided in PATH public use files was categorical and included the following groupings: 18 – 24, 25 – 34, 35 – 44, 45 – 54, 55 – 64, and 65+. Thus, individuals who were categorized as aged 18 – 24 at their Wave 7 interview were included in the current analyses.

**Measures**

***Pain Severity.*** Pain severity was assessed using a single item: “In the past 7 days, how would you rate your pain on average on a scale from 0 to 10, where 0 is no pain and 10 is the worst pain imaginable.” Prior research has shown associations with both past-week pain and more persistent measures of pain severity [36,37]. Scores were dichotomized as moderate to severe pain (scores > 4/10) and no to low pain (scores ≤ 4/10) consistent with previous research using the PATH study [25,38–41].

***E-Cigarette Use.*** Lifetime e-cigarette use; current, established e-cigarette use; and daily e-cigarette use were assessed using PATH-derived variables. Lifetime e-cigarette use (0 = non-use, 1 = lifetime use) was indicated by a response of “yes” to the following question: “Have you ever used electronic nicotine products, even one or two times?” Participants met the criteria for current, established e-cigarette use (0 = non-use, 1 = current, established use) if they endorsed the following: (1) lifetime use of electronic nicotine products (responded “yes” to “Have you ever used electronic nicotine products, even one or two times?”), (2) using e-cigarettes fairly regularly in the past (responded “yes” to “Have you ever used electronic nicotine products fairly regularly?”), and (3) current use e-cigarettes on some days or every day (responded “every day” or “some days” to “Do you now use electronic nicotine products every day, some days or not at all”). Participants were categorized as engaging in daily e-cigarette use (0 = non-use, 1 = daily use) if they met the criteria for current, established e-cigarette use, and endorsed using e-cigarettes every day.

***E-Cigarette Dependence.*** Dependence was measured using a tobacco dependence (TD) scale created for the PATH study [42], which assesses dependence across different nicotine and tobacco product types. The TD scale includes 16 items drawn from the Wisconsin Inventory of Smoking Dependence Motives [9,43] Tobacco Dependence Symptom Scale [44], and the Diagnostic and Statistical Manual, fifth edition [45], and assesses constructs such as automaticity, loss of control, negative reinforcement, craving, tolerance and withdrawal. The TD scale includes 15 items scored on a scale ranging from 1 (not true of me at all) to 5 (extremely true of me), and 1 binary item, with 0 = no, 1 = yes. Items are then summed to generate a composite TD score ranging from 15 – 76, with higher scores reflecting greater dependence symptoms. The TD scale has scale has been psychometrically validated as a measure of dependence across numerous tobacco products, including e-cigarettes [42], and higher TD scores have been shown to predict greater tobacco use frequency and lower odds of cessation [46]. In this sample, the internal consistency of the TD scale was excellent (*α* = 0.96).

***Other Tobacco Product Use*.**Other tobacco product use was measured according to the criteria for current, established use of the non-e-cigarette tobacco products assessed by the PATH study (i.e., cigarettes, traditional cigars, cigarillos, filtered cigars, pipe, hookah, snus, smokeless tobacco, or IQOS). For tobacco cigarettes, the criteria for current, established use were (1) ever cigarette use, (2) having smoked ≥ 100 cigarettes across lifetime, and (3) current use of cigarettes every day or on some days. The criteria for current, established use of other tobacco products were (1) ever use of the tobacco product, (2) regular use of the tobacco product in the past, and (3) current some day or every day use of the tobacco product. PATH derived variables were compiled into a dichotomous other tobacco product use variable, which was coded as 0 = no other tobacco use, and 1 = current, established use of any non-e-cigarette tobacco product.

***Dual Use of E-Cigarettes and Other Tobacco Products.*** Dual use of e-cigarettes and other tobacco products were compiled based on PATH derived variables. A categorical variable, indicating dual e-cigarette/other tobacco product use, was created and had following categorizations: 1) no tobacco product use, 2) exclusive e-cigarette use, 3) exclusive use of other tobacco products (i.e., cigarettes, traditional cigars, cigarillos, filtered cigars, pipe, hookah, snus, smokeless tobacco, or IQOS), and 4) dual use of e-cigarettes and other tobacco products.

***Sociodemographic Variables.*** Participants reported various sociodemographic characteristics, including gender (male, female), racial identity (White, Black, other), ethnicity (Hispanic, non-Hispanic), annual household income (< $10,000, $10,000 – $24,999 $25,000 – $49,999, $50,000 – $99,999, > $100,000), and education (less than high school, GED, high school graduate, some college or associate’s degree, bachelor’s degree or beyond).

**Data Analytic Plan**

All analyses were conducted using Stata Version 18.5 [47]. Missing values were present for all variables of interest, ranging from 0.02% – 8.3%. Missing data were excluded using listwise deletion, such that cases with missing values on any model variable were excluded from the relevant analysis. First, unweighted counts and weighted frequencies of sociodemographic and e-cigarette use characteristics were examined in the total sample and as a function of pain severity (i.e., no or low pain vs. moderate to severe pain). Chi-squared models were employed to test whether these proportions differed as a function of pain severity. Second, binary logistic regression models tested whether the presence of moderate to severe pain was associated with greater adjusted odds of (1) lifetime e-cigarette use; (2) current, established e-cigarette use; and (3) daily e-cigarette use. Third, a multinomial logistic regression model was used to determine whether moderate to severe pain (vs. no or low pain) was associated with a greater adjusted relative risk of exclusive e-cigarette use, exclusive use of other tobacco products, and dual use of e-cigarettes and other tobacco products, with no tobacco product use as the reference category. Fourth, the sample was limited to participants who engaged in current, established e-cigarette use, and a linear regression model tested associations between pain severity and TD scores. Given known associations with variables of interest [48–53], gender, race, ethnicity, education, and income were included as covariates in all models, and use of other tobacco products was included as a covariate in all models except for the one examining dual product use. Population and replicate weights were applied in all analyses to ensure representativeness and to account for complex sampling methods and non-response, per recommendations from the PATH study [34]. Balanced repeated replication methods were used to generate estimates, using Fay’s adjustment value of 0.3 [54].

**Results**

**Sample characteristics**

The current sample included 10,267 young adults aged 18 to 24 who provided data during Wave 7 of the PATH study. Participants were predominantly White (68%), and non-Hispanic (76%), and about 50% identified as female. Approximately 14% of young adults reported moderate/severe pain. The prevalence of current, established e-cigarette use was 25% among those with moderate/severe pain and 14% among those with no/low pain. Likewise, rates of daily e-cigarette use were about twice as high among individuals with moderate/severe pain, when compared to those with no/low pain (16% vs. 8%). Unweighted frequencies and weighted percentages of sociodemographic characteristics and e-cigarette use patterns, stratified by pain status, are displayed in Table 1. Across regression models, consistent patterns of associations between sociodemographic factors and primary outcome variables emerged. Specifically, racial identity of Black or Other, Hispanic ethnicity, female gender, and higher educational attainment were generally associated with lower odds of e-cigarette use, dual use, and tobacco dependence, while current use of other tobacco products and, in some cases, lower income levels were associated with greater odds of e-cigarette use.

**Associations between pain severity and odds of e-cigarette use**

Bivariate logistic regression analyses revealed that young adults with moderate to severe pain were 1.44 times as likely to report lifetime e-cigarette use, when compared to young adults with no or low pain (*aOR* = 1.44, 95% CI [1.25, 1.67], *p* < .001). Young adults with moderate to severe pain (vs. no or low pain) were 1.81 times as likely to engage in current, established e-cigarette use (*aOR* = 1.81, 95% CI [1.49, 2.20], *p* < .001), and were 1.89 times as likely to endorse current, established daily e-cigarette use (*aOR* = 1.89, 95% CI [1.53, 2.33], *p* < .001; see Table 2).

**Associations between pain severity and dual e-cigarette and tobacco product use**

Multinomial logistic regression analyses revealed that young adults with moderate to severe pain (vs. no or low pain) were 1.92 times as likely to exclusively use e-cigarettes (*RR* = 1.92, 95% CI [1.56, 2.36], *p* < .001), 1.94 times as likely to exclusively use other tobacco products (*RR* = 1.94, 95% CI [1.43, 2.65], *p* < .001), and were 2.58 times as likely to engage in dual use of e-cigarettes and other tobacco products (*RR* = 2.58, 95% CI [1.92, 3.49], *p* < .001; See Table 3).

**Associations between pain severity and e-cigarette dependence**

Linear regression analyses were used to examine TD scores among participants who endorsed current, established e-cigarette use. Results indicated that the presence of moderate to severe pain (vs. no or low pain) was positively associated with TD scores (*b* = 2.33, *SE* = 1.03, *p* = .026; see Table 4), reflecting modestly greater e-cigarette dependence symptoms among individuals with moderate to severe pain.

**Discussion**

The present analyses are first to examine cross-sectional associations between pain severity and e-cigarette use among a nationally representative sample of young adults at Wave 7 (2022 – 2023) of the PATH Study. Consistent with hypotheses, the presence of moderate to severe pain was associated with greater odds of lifetime e-cigarette use; current, established e-cigarette use; and current, daily e-cigarette use among young adults. The rates of current, established e-cigarette use and daily e-cigarette use among young adults with pain were about 25% and 15% respectively, or roughly double the rates observed in young adults without no or low pain. Importantly, these results were observed even after accounting for known correlates of e-cigarette use. Previous research indicates robust associations between both male gender and other tobacco product use and greater odds of e-cigarette use among young adult populations [55], which broadly aligns with the current findings.

Consistent with prior research among the general adult population [24–27,56], the current findings suggest that moderate to severe pain may serve as a risk factor for e-cigarette use, heavier patterns of use (i.e., daily use), and greater tobacco dependence among young adults. Furthermore, results indicated that young adults with pain were more than 2.5 times as likely to engage in dual use of e-cigarettes and other tobacco products when compared to those with no or low pain. This broadly aligns with prior work demonstrating that in the general adult population, cigarette smoking adults with pain are more likely to use other nicotine and tobacco products [24,25], perhaps as a means to supplement or increase nicotine intake, as nicotine confers acute analgesic effects [23]. Furthermore, the current findings suggest that healthcare providers may benefit from screening for e-cigarette use and dependence among young adults receiving treatment for pain.

Targeted interventions that provide personalized feedback and psychoeducation about pain-smoking interrelations have garnered success in increasing motivation to quit smoking and cessation treatment engagement among individuals with co-occurring pain and cigarette smoking [57–59]. Among the current sample, approximately 1 in 4 young adults with pain engaged in current, established e-cigarette use, indicating that investigation of the potential clinical utility of targeted e-cigarette cessation interventions among young adults with pain is warranted. Notably, young adults are more likely to initiate use of tobacco products compared to other age groups [60], and e-cigarette use has been linked with subsequent initiation of cigarette smoking among non-smoking young adults [13,14]. Further research should examine the utility of both e-cigarette cessation and cigarette smoking prevention efforts targeting young adults who experience pain and e-cigarette use, perhaps through interventions providing psychoeducation about interrelations between pain and tobacco product use [57–59].

This study has several limitations. First, these findings are cross-sectional, precluding causal inferences or interpretation. Second, because these analyses employed a dichotomous indicator of past-week pain severity, future research would benefit from examining interplay between e-cigarette use and more granular measures of pain severity, including the presence of chronic pain [56] and functional impairment [61]. Third, the current study did not assess cognitive-affective transdiagnostic vulnerability factors (e.g., pain-related anxiety, anxiety sensitivity, distress tolerance) which have been shown to play an explanatory role in the presence of co-occurring pain and use of nicotine/tobacco products [21,26,62–65]. Fourth, use of flavored e-cigarettes, which are popular among young adults and have been linked to greater e-cigarette dependence [66], were not examined. Given that previous research has shown links between pain and the use of menthol cigarettes [38], future work would benefit from examining associations between pain, nicotine dependence, and use of e-cigarettes with menthol or synthetic cooling flavors [67].

In summary, the present findings indicate that among a nationally representative sample of young adults aged 18 – 24, pain was associated with greater odds of e-cigarette use, dual use of e-cigarettes and other tobacco products, and greater e-cigarette dependence. These findings suggest the potential clinical utility of targeted e-cigarette prevention and cessation interventions for young adults with pain. Future research should also examine longitudinal trajectories of pain and e-cigarette use among young adults.

**Informed consent:** Informed consent was obtained from all individual participants included in the Population Assessment of Tobacco and Health (PATH) study.

**Ethical approval**: All procedures performed in the Population Assessment of Tobacco and Health (PATH) study were in accordance with the ethical standards of the 1964 Helsinki declaration and were approved by the Institutional Review Board at Westat. This article does not contain any studies with animals performed by any of the authors

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**Table 1.** *Sociodemographic Characteristics as a Function of Pain Severity Among Young Adults (Age 18 –* *24) at Wave 7 (2022 –* *2023) of the PATH Study*

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Total Sample** | **No or Low Pain** | **Moderate or Severe Pain** |
|  | *n* (%) | *n* (%) | *n* (%) |
| **Gender\*** |  |  |  |
| Female | 5,305 (49.73) | 4,462 (49.22) | 843 (52.78) |
| Male | 5,221 (50.27) | 4,515 (50.78) | 706 (47.22) |
| **Race\*\*** |  |  |  |
| White | 6,462 (68.01) | 5,605 (68.81) | 857 (63.20) |
| Black | 1,780 (14.82) | 1,445 (14.08) | 335 (19.30) |
| Other | 1,690 (17.17) | 1,425 (17.11) | 265 (17.50) |
| **Ethnicity\*** |  |  |  |
| Hispanic | 3,244 (23.77) | 2,769 (23.31) | 495 (26.50) |
| **Past-year annual income\*\*** |  |  |  |
| < $10,000 | 1,794 (16.92) | 1,430 (15.95) | 364 (22.83) |
| $10,000 - $24,999 | 1,746 (16.87) | 1,446 (16.17) | 300 (21.10) |
| $25,000 - $49,999 | 2,131 (21.40) | 1,822 (21.35) | 309 (21.72) |
| $50,000 - $99,999 | 2,119 (22.33) | 1,841 (22.59) | 278 (20.79) |
| > $100,000 | 1,900 (22.47) | 1,737 (23.95) | 163 (13.56) |
| **Education\*\*** |  |  |  |
| Less than high school | 1,099 (10.69) | 845 (9.61) | 254 (17.14) |
| GED | 256 (2.68) | 205 (2.49) | 51 (3.80) |
| High school graduate | 3,838 (32.39) | 3,210 (31.83) | 628 (35.77) |
| Some college or associate’s | 4,067 (41.12) | 3,554 (42.04) | 513 (42.04) |
| Bachelor’s degree | 1,257 (13.13) | 1,154 (14.03) | 103 (7.71) |
| **Lifetime e-cigarette use\*\*** | 5,227 (51.26) | 4,331 (49.80) | 896 (60.01) |
| **Current, established e-cigarette use\*\*** | 1,574 (15.67) | 1,227 (14.17) | 347 (24.71) |
| **Current, established daily e-cigarette use\*\*** | 930 (9.47) | 708 (8.40) | 222 (15.88) |
| **Exclusive e-cigarette use\*\*** | 1,253 (12.38) | 998 (11.42) | 255 (18.17) |
| **Exclusive other tobacco product use\*\*** | 333 (3.29) | 252 (2.97) | 81 (5.21) |
| **Dual e-cigarette/other tobacco use\*\*** | 321 (3.29) | 229 (2.75) | 92 (6.54) |

*Note.* Table lists unweighted count and weighted percentage; Weighted prevalence estimates used population weights, which used balanced repeated replication with Fay’s adjustment of 0.3; No or low pain: pain severity ≤ 4/10; Moderate to severe pain: pain severity > 4/10; Other: American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, Multiracial; GED: General Educational Development test; \**χ*2 significant at *p* < .05, \*\**χ*2 significant at *p* < .001.

**Table 2.** *Binary logistic regression models of associations between pain severity and odds of 1) lifetime e-cigarette use; 2) current, established e-cigarette use; and 3) current, established daily e-cigarette use.*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Lifetime e-cigarette use**  **(Model 1)** | | | **Current established e-cigarette use (Model 2)** | | | **Current established daily e-cigarette use (Model 3)** | | |
|  | *aOR* | [95% CI] | *p* | *aOR* | [95% CI] | *p* | *aOR* | [95% CI] | *p* |
| **Pain Severity a** |  |  |  |  |  |  |  |  |  |
| No/low pain | [REF] |  |  |  |  |  |  |  |  |
| Moderate/severe pain | 1.44 | [1.25 – 1.67] | < .001\*\* | 1.81 | [1.49 – 2.20] | < .001\*\* | 1.89 | [1.53 – 2.33] | < .001\*\* |
| **Gender** |  |  |  |  |  |  |  |  |  |
| Male | [REF] |  |  |  |  |  |  |  |  |
| Female | 1.09 | [0.99 – 1.20] | .068 | 0.99 | [0.87 – 1.14] | .931 | 1.08 | [0.91 – 1.29] | .352 |
| **Race** |  |  |  |  |  |  |  |  |  |
| White | [REF] |  |  |  |  |  |  |  |  |
| Black | 0.55 | [0.47 – 0.64] | < .001\*\* | 0.33 | [0.24 – 0.45] | < .001\*\* | 0.23 | [0.15 – 0.35] | < .001\*\* |
| Other | 0.77 | [0.68 – 0.88] | < .001\*\* | 0.84 | [0.70 – 1.00] | .045\* | 0.87 | [0.70 – 1.08] | .202 |
| **Ethnicity** |  |  |  |  |  |  |  |  |  |
| Hispanic | [REF] |  |  |  |  |  |  |  |  |
| Non-Hispanic | 1.17 | [1.00 – 1.38] | .053 | 1.90 | [1.57 – 2.32] | < .001\*\* | 2.55 | [1.96 – 3.31] | < .001\*\* |
| **Past-year income** |  |  |  |  |  |  |  |  |  |
| < $10,000 | [REF] |  |  |  |  |  |  |  |  |
| $10,000 – $24,999 | 1.20 | [1.02 – 1.41] | .028\* | 1.05 | [0.84 – 1.32] | .660 | 1.44 | [1.08 – 1.94] | .015\* |
| $25,000 – $49,999 | 1.31 | [1.13 – 1.52] | .001\* | 1.17 | [0.92 – 1.50] | .195 | 1.72 | [1.25 – 2.38] | .001\* |
| $50,000 – $99,999 | 1.14 | [0.95 – 1.37] | .169 | 1.11 | [0.86 – 1.44] | .403 | 1.45 | [1.04 – 2.03] | .029\* |
| > $100,000 | 1.02 | [0.86 – 1.22] | .787 | 0.85 | [0.67 – 1.08] | .191 | 1.04 | [0.78 – 1.38] | .783 |
| **Education b** |  |  |  |  |  |  |  |  |  |
| Less than high school | [REF] |  |  |  |  |  |  |  |  |
| GED | 1.64 | [1.04 – 2.59] | .033\* | 1.44 | [0.97 – 2.14] | .068 | 1.68 | [1.10 – 2.57] | .016\* |
| High school graduate | 1.15 | [0.94 – 1.40] | .181 | 1.02 | [0.80 – 1.30] | .863 | 0.86 | [0.67 – 1.12] | .269 |
| Some college/associate’s | 1.26 | [1.04 – 1.52] | .019\* | 1.07 | [0.82 – 1.38] | .627 | 0.85 | [0.64 – 1.11] | .226 |
| Bachelor’s or above | 1.27 | [1.03 – 1.58] | .027\* | 0.67 | [0.47 – 0.94] | .020\* | 0.41 | [0.27 – 0.63] | < .001\*\* |
| **Other tobacco product use c** |  |  |  |  |  |  |  |  |  |
| No | [REF] |  |  |  |  |  |  |  |  |
| Yes | 11.19 | [8.15 – 15.4] | < .001\*\* | 5.37 | [4.31 – 6.70] | < .001\*\* | 3.34 | [2.63 – 4.23] | < .001\*\* |

*Note.* All models employed population weights, which used balanced repeated replication with a Fay’s adjustment of 0.3; Current, established e-cigarette use = participants who endorsed regular use of e-cigarettes on some days or daily; Current, established daily e-cigarette use = participants who met criteria for current, established e-cigarette use and report using e-cigarettes on every day; a No or low pain: pain severity ≤ 4/10; Moderate to severe pain: pain severity > 4/10; b GED: General Educational Development test; c Other tobacco product use = current, established use of cigarettes, traditional cigars, cigarillos, filtered cigars, pipe, hookah, snus, smokeless tobacco, or IQOS; \* *p* < .05, \*\* *p* < .001.

**Table 3.** *Multinomial logistic regression model of associations between pain severity and odds of exclusive and dual use of e-cigarettes and other tobacco products.*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Exclusive e-cigarette use** | | | **Exclusive other tobacco**  **product use** | | | **Dual e-cigarette and other tobacco product use** | | |
|  | *RR* | [95% CI] | *p* | *RR* | [95% CI] | *p* | *RR* | [95% CI] | *p* |
| **Pain severity a** |  |  |  |  |  |  |  |  |  |
| No/low pain | [REF] |  |  |  |  |  |  |  |  |
| Moderate/severe pain | 1.92 | [1.56 – 2.36] | < .001\*\* | 1.94 | [1.43 – 2.65] | < .001\*\* | 2.58 | [1.92 – 3.49] | < .001\*\* |
| **Gender** |  |  |  |  |  |  |  |  |  |
| Male | [REF] |  |  |  |  |  |  |  |  |
| Female | 0.96 | [0.84 – 1.11] | .573 | 0.53 | [0.43 – 0.69] | < .001\*\* | 0.65 | [0.46 – 0.91] | .012\* |
| **Race** |  |  |  |  |  |  |  |  |  |
| White | [REF] |  |  |  |  |  |  |  |  |
| Black | 0.33 | [0.23 – 0.45] | < .001\*\* | 0.83 | [0.56 – 1.22] | .340 | 0.29 | [0.17 – 0.50] | < .001\*\* |
| Other | 0.80 | [0.66 – 0.97] | .024\* | 0.69 | [0.46 – 1.02] | .059 | 0.73 | [0.49 – 1.08] | .117 |
| **Ethnicity** |  |  |  |  |  |  |  |  |  |
| Hispanic | [REF] |  |  |  |  |  |  |  |  |
| Non-Hispanic | 2.05 | [1.66 – 2.52] | < .001\*\* | 2.33 | [1.73 – 3.12] | < .001\*\* | 2.88 | [1.96 – 4.24] | < .001\*\* |
| **Past-year income** |  |  |  |  |  |  |  |  |  |
| < $10,000 | [REF] |  |  |  |  |  |  |  |  |
| $10,000 – $24,999 | 1.02 | [0.79 – 1.32] | .864 | 0.89 | [0.62 – 1.29] | .541 | 1.05 | [0.70 – 1.56] | .826 |
| $25,000 – $49,999 | 1.21 | [0.93 – 1.58] | .151 | 0.98 | [0.67 – 1.44] | .922 | 0.87 | [0.60 – 1.28] | .472 |
| $50,000 – $99,999 | 1.05 | [0.79 – 1.41] | .714 | 0.51 | [0.32 – 0.81] | .005\* | 0.75 | [0.49 – 1.17] | .203 |
| > $100,000 | 0.79 | [0.61 – 1.02] | .070 | 0.29 | [0.17 – 0.49] | < .001\*\* | 0.44 | [0.28 – 0.70] | .001\* |
| **Education b** |  |  |  |  |  |  |  |  |  |
| Less than high school | [REF] |  |  |  |  |  |  |  |  |
| GED | 1.46 | [0.90 – 2.37] | .124 | 1.58 | [0.80 – 3.13] | .183 | 2.35 | [1.20 – 4.61] | .013\* |
| High school graduate | 0.98 | [0.75 – 1.29] | .869 | 0.57 | [0.37 – 0.90] | .016\* | 0.66 | [0.40 – 1.06] | .085 |
| Some college/associate’s | 0.99 | [0.76 – 1.29] | .963 | 0.33 | [0.21 – 0.52] | < .001\*\* | 0.49 | [0.29 – 0.84] | .010\* |
| Bachelor’s or above | 0.63 | [0.43 – 0.91] | .015\* | 0.26 | [0.14 – 0.51] | < .001\*\* | 0.24 | [0.12 – 0.45] | < .001\*\* |

*Note.* The model employed population weights, which used balanced repeated replication with a Fay’s adjustment of 0.3; Exclusive e-cigarette use = current, established e-cigarette user without use of tobacco products (i.e., cigarettes, traditional cigars, cigarillos, filtered cigars, pipe, hookah, snus, smokeless tobacco, or IQOS); Exclusive other tobacco product use = current, established use of cigarettes, traditional cigars, cigarillos, filtered cigars, pipe, hookah, snus, smokeless tobacco, or IQOS., without current, established e-cigarette use; Dual e-cigarette and other tobacco product use = both current, established e-cigarette use and current, established other tobacco product use (i.e., cigarettes, traditional cigars, cigarillos, filtered cigars, pipe, hookah, snus, smokeless tobacco, or IQOS); a No or low pain: pain severity ≤ 4/10; Moderate to severe pain: pain severity > 4/10; b GED: General Educational Development test; \* *p* < .05, \*\* *p* < .001.

**Table 4.** *Linear regression model of associations between pain severity and e-cigarette dependence.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Tobacco dependence Score** | | | |
|  | *b* | linearized SE | *t* | *p* |
| **Pain severity** |  |  |  |  |
| No/low pain | [REF] |  |  |  |
| Moderate/severe pain | 2.33 | 1.03 | 2.26 | .026\* |
| **Gender** |  |  |  |  |
| Male | [REF] |  |  |  |
| Female | 3.06 | 1.19 | 2.56 | .012\* |
| **Race** |  |  |  |  |
| White | [REF] |  |  |  |
| Black | -10.83 | 1.45 | -7.48 | < .001\*\* |
| Other | -0.44 | 1.75 | -0.25 | .800 |
| **Ethnicity** |  |  |  |  |
| Hispanic | [REF] |  |  |  |
| Non-Hispanic | 6.24 | 1.30 | 4.78 | < .001\*\* |
| **Past-year income** |  |  |  |  |
| < $10,000 | [REF] |  |  |  |
| $10,000 – $24,999 | 4.20 | 1.77 | 2.37 | .020\* |
| $25,000 – $49,999 | 4.71 | 1.80 | 2.62 | .010\* |
| $50,000 – $99,999 | 2.57 | 1.82 | 1.42 | .160 |
| > $100,000 | 1.92 | 1.78 | 1.08 | .284 |
| **Education** |  |  |  |  |
| Less than high school | [REF] |  |  |  |
| GED | 2.67 | 2.62 | 0.74 | .463 |
| High school graduate | -1.80 | 1.72 | -1.05 | .296 |
| Some college/associate’s | 0.40 | 1.77 | 0.23 | .820 |
| Bachelor’s or above | -0.41 | 2.40 | -0.17 | .865 |
| **Other Tobacco Product Use** |  |  |  |  |
| No | [REF] |  |  |  |
| Yes | -2.58 | 1.47 | -1.75 | .083 |

*Note.* The model employed population weights, which used balanced repeated replication with a Fay’s adjustment of 0.3; No or low pain: pain severity ≤ 4/10; Moderate to severe pain: pain severity > 4/10; GED: General Educational Development test; Other tobacco product use = current, established use of cigarettes, traditional cigars, cigarillos, filtered cigars, pipe, hookah, snus, smokeless tobacco, or IQOS; \* *p* < .05, \*\* *p* < .001.